THE ECONOMICS OF WHITE PINE BLISTER RUST CONTROL IN THE LAKE STATES

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by

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C. H. Stoltenberg of the Northeastern Forest Experiment Station had primary responsibility for designing the project plan, and with R. J. Marty, designed and conducted the weevil-damage surveys, analyzed the results, appraised the effects on pine yields of various management treatments, developed the management guides and methods of application, and coauthored the final report.

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PREFACE

This publication summarizes the results of an analysis of the economic aspects of protecting eastern white pine in the Lake States region from attack by the parasitic fungus, blister rust. The disease kills large numbers of trees in many unprotected young white pine stands, but it can be controlled. Under authority of the Lea Act of 1940, the U.S. Forest Service is responsible for leadership, coordination, and technical direction of white pine blister rust control activities on forest lands of all ownerships.

One responsibility of the Forest Service in this program is investment of available rust control funds in areas that will return greatest benefits in pine values saved by control measures. In advising States and other agencies regarding the advisability of rust control work, as well as in planning its own expenditures, the Forest Service also is responsible for estimating the total amount of public funds which should be invested in blister rust control. An improved basis for making these decisions in the Lake States has been needed.

Consequently, our aim here is to provide guides for those responsible for the formulation and execution of the white pine blister rust control policies and program in the Lake States region. This publication describes an improved method for estimating the magnitude of monetary benefits to the economy that can be expected to result from blister rust control in individual white pine stands. A control program based on such an analysis will assure expenditure of control funds on areas that will return maximum economic benefits.

No attempt is made to appraise the profitability of past rust control efforts, since the objective is to help evaluate future courses of action. For example, in some stands blister rust can be controlled at low cost because of past investments in control work. Because past investments cannot be retracted, plans for future rust control must be based on the status of the white pine resource today. Accordingly, our analysis considers the economic future of the white pine resource based on costs and benefits of rust control with and without other management alternatives which could be applied in the immediate future.

The report first describes the current white pine resource in the Lake States, indicating what managerial opportunities are available.

Next, we consider special problems limiting production of white pine, and the opportunities for increasing the volume and value of white pine produced by blister rust control along with various other management measures under different stand and site conditions.

Current and prospective markets are next analyzed, because the nature of future markets indicates what future white pine values are likely to be.

These elements are then combined to determine the relationship between rust control costs and the value of pine that could be saved by rust control in existing young Lake States forests--the economic basis for selecting the most profitable areas in which to concentrate control effort.

The final section considers the regional implications of applying these criteria to existing Lake States pine stands. It provides a basis for evaluating the effects that adoption of these criteria would have on the present rust control program, a general description of the potential pine values at stake, and a basis for allotting rust control funds to areas that will return the greatest profits on such investments.

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THE ECONOMICS OF WHITE PINE BLISTER RUST CONTROL IN THE LAKE STATES

SUMMARY AND CONCLUSIONS

The principal findings and conclusions of this analysis may be summarized as follows:

1. Timber stands containing significant numbers of eastern white pine trees now occupy about 1 1/4 million acres in the three Lake States, according to records of the Forest Service, Branch of Forest Pest Control. White pine on these areas generally occurs in mixture with many other species, although some almost pure pine stands are present.

The white pine resource in the Lake States is a young resource. Pine stands less than 30 years old occupy 765,000 acres, almost two-thirds of the total white pine area. Stands with pine less than 50 years old occupy almost 900,000 acres and those 50 years and older, about 350,000 acres. Stocking of white pine is generally low, with less than half full pine stocking on more than five-sixths of the 900,000 acres occupied by young stands less than age 50.

The potential yield of fully stocked stands on productive sites is very high. Yields exceeding 50,000 board feet per acre in 120 years are possible on areas of site index 60, which are most prevalent. Site productivity generally is high in the southern and low in the northern parts of the Region. About 90 percent of the pine area in southern Wisconsin is classified good in productivity, compared with less than 20 percent in northern Minnesota. The present volume of white pine sawtimber totals 3.4 billion board feet, most of which is concentrated in relatively few old-growth stands.

2. Growing quality white pine involves special protection and management problems. White pine blister rust kills more white pines than any other disease. Pine mortality caused by blister rust in the Lake States is greatest in the north and diminishes southward. Losses without rust control in the northern, high rust-hazard zone during a 100-year rotation average two-thirds of desirable dominant pines in the stand, compared with less than one-tenth in the southern low rust-hazard zone. Blister rust can be controlled by destroying all currant and gooseberry bushes within infecting distance of white pine. Rust control costs vary among stands from less than 0.1 to more than 3 man-days per acre in the Lake States, and average about 0.15 man-day per acre of pine area treated.

Damage by the white pine weevil generally causes serious loss in both pine volume and quality, and repeated attacks sometimes make entire trees worthless for forest products. Incidence of weevil damage is twice as great in the southern as in the northern part of the region. Weevil damage can be held at an acceptable level by maintaining an overstory, or controlled by spraying insecticides on the pine terminals from the ground. The amount of damage caused by weevil depends upon the frequency of attack and on management, site, and stand conditions.

Release from competing species often is required. Until they are 6 to 8 feet tall, white pines on good sites often are unable to keep ahead of competing hardwoods, and if release is delayed until this time, many pines die. Almost half the area with young pine stands, 400 thousand acres, contains at least 50 well-spaced suppressed pines per acre that could become crop trees if released.

Thinning and pruning can greatly increase pine values. About 400 thousand acres support young pine stands of sufficient density to provide one or more intermediate cuts. More than 800 thousand acres contain pine stands averaging less than 6 inches d.b.h. that would benefit considerably from pruning.

3. How profitable blister rust control will be in any stand depends in part upon the value of the pine saved. This in turn depends upon future markets. Today practically all eastern white pine harvested is used to make lumber, used primarily for construction, containers, or manufactured products such as millwork and furniture. Most high-quality white pine lumber produced is used for manufactured products.

The lower grades generally are sold in construction and container markets, where quality is of less importance.

With the great future expansion in the Nation's population and the economy that is anticipated, markets for white pine lumber should be substantially stronger for all major uses. Recent Forest Service projections indicate a potential demand by the year 2000 for almost double the volume of construction lumber, and a two-thirds greater volume of container lumber than was consumed in 1952. Nevertheless, these markets for low-grade lumber presumably will be highly competitive, as they are today, with prices based on major competing species more plentiful than eastern white pine.

The market outlook for high-quality eastern white pine is much more promising. Projections indicate a potential lumber demand for manufacturing use in the year 2000 twice the volume consumed for this use in 1952. Markets in 1948 (the most recent data available) for lumber of grades suitable for manufacturing use were 20 times the volume of eastern white pine so used, and the available volume of suitable grades of competing species is constantly declining. Thus, where high-quality white pine can be grown, there is a strong economic incentive for protecting and managing this species.

The value of eastern white pine stumpage of average size and quality currently being harvested is estimated at $20 per thousand board feet. Projected values used for this study increase gradually, about $2 every 10 years. Protection and management measures which increase tree quality will, of course, produce stumpage having considerably greater than average values.

4. A method of rating the profitability of rust control was developed by combining estimates of current protection costs, future values of various grades of white pine, and the effects of protection and management treatments on future pine volumes and grades. Three working tools to simplify field application include a field tally form, computation sheet, and a set of matched data cards called the "Calculation Aid." The Calculation Aid is used somewhat like a slide rule and readily provides results of computations pertaining to potential pine yield, quality, and value; losses caused by blister rust and weevil; and other related factors that affect rust control profitability. Complete instructions for its use are attached as a field manual (Appendix B).

5. Because of past rust control efforts and the advanced age of some stands, important value savings from future control measures are possible on only 479,000 of the entire 1-1/4 million acres of white pine area in the Lake States. According to this analysis, additional rust control treatment will be profitable on two-thirds of these prospective control areas, that is, on 320,000 acres.

The proportion of pine area on which pine values saved will exceed rust control costs varies by subregions. In northern Wisconsin, for example, additional rust control effort on most of the 136,000 acres of prospective control area appears to be profitable, compared to 66 percent of the area in the southern peninsula of Michigan, 36 percent in northern Minnesota, and very little in southern Wisconsin. The above estimates refer only to areas where rust control appears profitable with no other management measures applied. With other management treatments also applied, rust control appears profitable on as much as 118,000 additional acres, depending on the combination of treatments used.

6. The potential volume of pine that could be saved by rust control, on areas which can be profitably treated, is 2.2 to 2.9 billion board feet depending on the number of other management measures also applied. Almost three-fourths of this additional volume could be saved in the northern, high rust-hazard zone, compared with 19 percent in the medium and 7 percent in the southern low hazard zone. Half the potential white pine volume that could be saved by future rust control work in all existing Lake States stands is in the high hazard zone of northern Wisconsin.

The gross value of the pine that could be saved by rust control on areas where control appears profitable depends greatly upon what other management treatments the stands receive. If no other management is provided, savings from control amount to 106 million dollars. This amount increases to $291 million if weevil control, release, and thinning and pruning treatments also are applied.

7. Establishing rust control on all the 320,000 acres where treatment appears profitable would require about 113,000 man-days of field labor. At the present level of expenditures for rust control in the Lake States, about 8 years would elapse before control would be established on these areas. If done now, this would mean a cash outlay of $3.2 million, which, with additions

of margin for risk and $2\frac{1}{2}$ percent compound interest, would increase to $28.5 million by the time these existing stands mature.

Thus the average ratio of returns to costs, with 2.5 percent interest and allowance for risk, is about 4 to 1 for rust control investments on all areas where benefits exceed costs. This represents an eventual return of $26 for every $1 of initial cash outlay.

8. The ratio of returns to costs in different areas must also be considered if funds available are insufficient to treat all pine stands where additional control work is believed profitable. The greatest area offering high returns on rust control investments is in northern Wisconsin. Stands which can return five or more times treatment costs plus 2.5 percent interest total 65,000 acres in northern Wisconsin compared with 4,000 acres in northern Minnesota, 21,000 acres in northern Michigan, and practically none in the entire medium and low rust-hazard zones. The medium and low hazard zones contain about 150 thousand acres where rust control would be profitable, but returns would average only $2.50 per dollar spent for control.

9. Future benefits exceed costs of rust control (including interest and risk) on from 320,000 to 440,000 acres in the Lake States region. Immediate control efforts will yield the greatest benefits if work is concentrated in the northern, high rust-hazard zone, especially in northern Wisconsin. The evaluation procedure developed by this study can help guide field personnel in selecting the particular pine areas where blister rust control investments will yield the greatest economic benefits.

THE PRESENT WHITE PINE RESOURCE IN THE LAKE STATES

White Pine Area Based on BRC Records

Records of the Forest Service blister rust control (BRC) program were considered the most complete source of available data regarding the extent and location of white pine areas in the Lake States, and were used as the basis for this analysis. These area records were accumulated during the past 30 years of blister rust control work, and generally include all known white pine areas of 20 or more continuous acres, plus some additional areas of 10 or more acres with high recreational values or exceptional site productivity.

The acreage of white pine areas in the Lake States according to BRC records is three times that reported in the Forest Survey, mainly because of differences in classification standards. For rust control purposes, forest areas supporting significant numbers of white pine trees are classified as white pine areas, whereas Forest Survey type classification is based on the primary forest type dominating each area. Thus an area supporting a young white pine stand with an overstory of aspen sawtimber would be classified as a white pine area by BRC standards, and as an aspen sawtimber area by the Forest Survey.

White Pine Area Exceeds Million Acres

Timber stands containing significant numbers of eastern white pine (*Pinus strobus* L.) now occupy about 1-1/4 million acres in the Lake States (table 1),[1] and are distributed among the three States (fig. 1) as follows:

	Thousand acres
Lake States:	
Minnesota	233
Wisconsin	553
Michigan	460
Total	1,246

Pine Generally Grows in Scattered Mixed Stands

The white pine area is not a continuous, unbroken stand. White pine generally occurs in scattered stands (fig. 2) which vary in size from a few acres to more than a thousand acres. This patchy occurrence of white pine makes protection and management of the species more difficult.

[1] All numbered tables are in Appendix A.

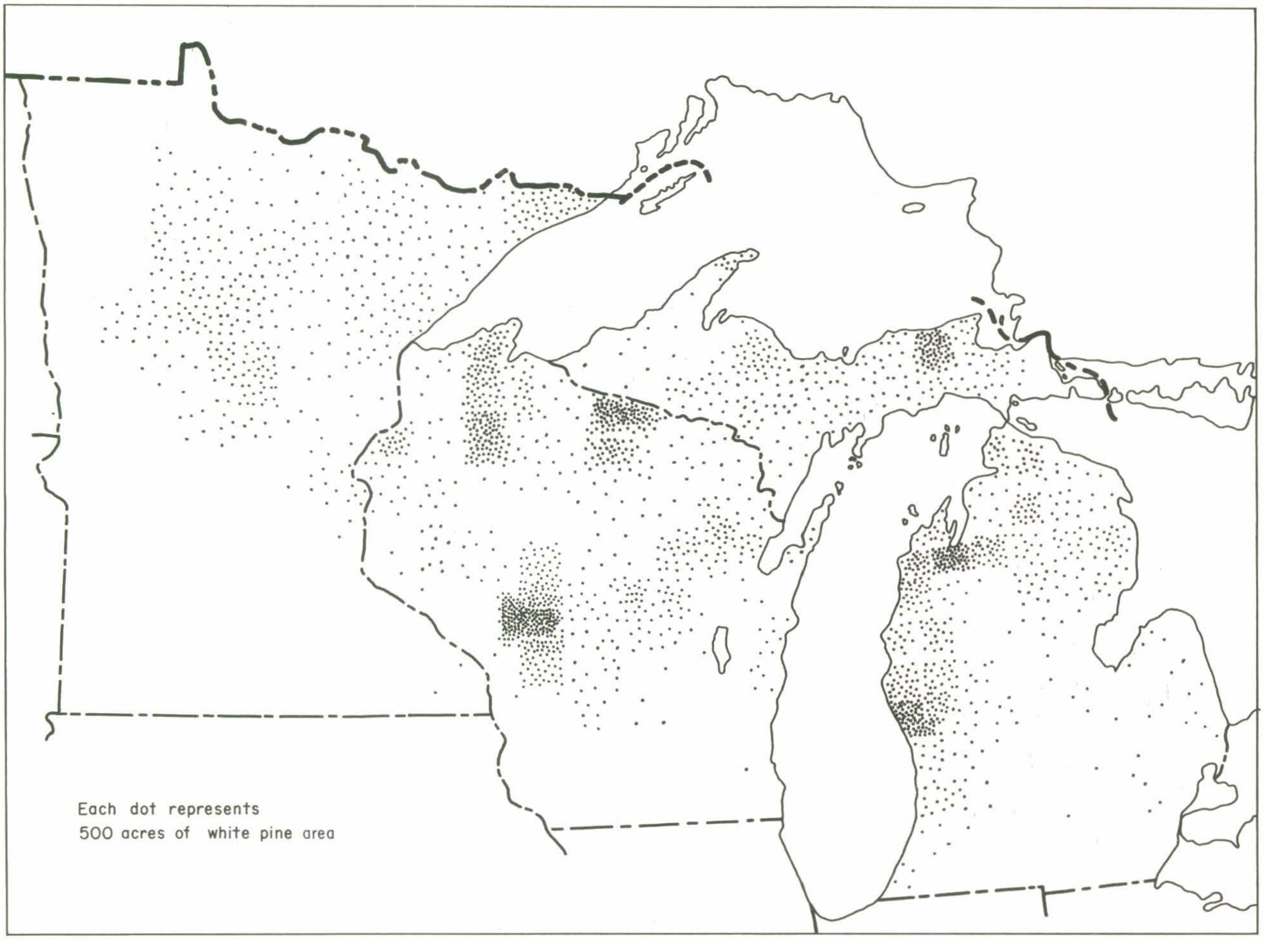

Figure 1.--Distribution of white pine area included in the Lake States blister rust control program, 1957.

White pine generally grows in mixture with other species, although pure stands sometimes develop following fire, windthrow, or abandonment of agricultural lands (fig. 3). On dry sandy soils in the Lake States it usually grows in mixture with aspen, various oaks, balsam fir, red pine, or jack pine. On heavier soils it is more likely to grow with yellow or paper birch, maple, hemlock, red oak, or aspen.

During the first few years after germination, white pine seedlings grow slowly. Even after 8 years few trees are likely to be more than 5 feet tall. This slow early growth puts white pine at a disadvantage with many of its competitors, particularly with those species which sprout aggressively. On the heavier soils, competing species often crowd out young pine before its rapid growth begins. However, if not overtopped, white pines at about 10 to 15 years of age begin to grow rapidly in height--1 to 3 feet per year, depending on site quality.

On lighter, drier soils, white pine competes more successfully with associated species. Even though other species overtop it, white pine generally will exist in the understory for many years, eventually overtopping such species as oak and aspen after 30 to 50 years.

White pine is a long-lived tree. In natural stands it commonly reaches 300 years of age, and grows well throughout its lifetime. Under favorable conditions it frequently reaches heights of more than 100 feet and diameters of 3 to 6 feet (fig. 4). Under management, trees this large generally will not be grown. As pine trees reach 80 to 100 years of age they usually have a large conversion value. Even though their value growth remains high at this

Figure 2.--White pine in the Lake States generally grows in scattered stands.

age, it is becoming smaller relative to the value of the tree; before long this rate of return on the conversion value of trees falls below the rate that could be earned if the trees were harvested and the income invested in forest practices elsewhere in the stand. Thus, economic rotations for most stands in the Lake States are between 80 and 120 years.

Pine Stocking Is Low

The stocking of white pine trees in Lake States stands is generally low, mainly because most pines grow in mixed stands where other species occupy much of the growing space. Pine stocking is an important factor affecting the profitability of rust control since, with the yield tables available for this study, the volume of expected yield depends greatly on the number of pines per acre.

The term "full stocking" is used as a common denominator in comparisons of existing stocking with that desired in stands of various age on different sites. Full stocking is defined here as the level of stocking in a forest stand at which all growing space is effectively occupied, but with ample room for best development of the crop trees. In stands 50 years and older, 130 square feet of pine basal area per acre was considered full stocking. In younger stands the level of stocking was based on the number of dominant and codominant pines per acre and the site index (described later). The required number of pines per acre for full stocking was as follows:

Site Index:	Pines per acre (number)
40	650
50	570
60	480
70	420
80	390

This analysis did not evaluate the profitability of rust control in pine stands more

Figure 3.--Pure pine stands sometimes develop following fire or windthrow, or abandonment of agricultural lands.

than 50 years old because, with the relatively short rotations assumed in this study, they generally are too old for profitable rust control treatment.

Estimates of pine stocking in stands less than 50 years of age were made under each of two assumptions regarding future management. With no release treatment anticipated, the estimates include only existing stocking of relatively free-growing dominant and codominant pines which are expected to grow and develop satisfactorily without release or thinning treatment. With release anticipated, estimates of stocking also included any additional suppressed pines which could be released by removal of overtopping competitors of other species. With both assumptions, stocking included only well-distributed pines with spacing which provides maximum stands of from 390 to 650 stems per acre depending on site as shown above.

Figure 4.--Under favorable conditions, white pines commonly grow more than 100 feet high, with diameters of 3 to 6 feet. (F-433058)

Without release, less than one-sixth of the area in stands less than 50 years of age supports pine with density exceeding 50 percent of full stocking (table 2). Less than two-fifths of the area exceeds 30 percent of full stocking. About 45,000 acres, 5 percent of the area, contains no free-growing dominant or codominant pines, but does contain suppressed pines which could be released.

With release, pine stocking of these younger stands can be considerably improved. The proportion of total area exceeding 50 percent of full pine stocking would become 63 percent, as against 16

percent without release, and the proportion of area exceeding 30 percent of full pine stocking could be 80 percent as against the former 39 percent (fig. 5). Furthermore, some 45,000 acres containing suppressed pines, but no free-growing crop trees, could be added to the white pine resource by release treatment.

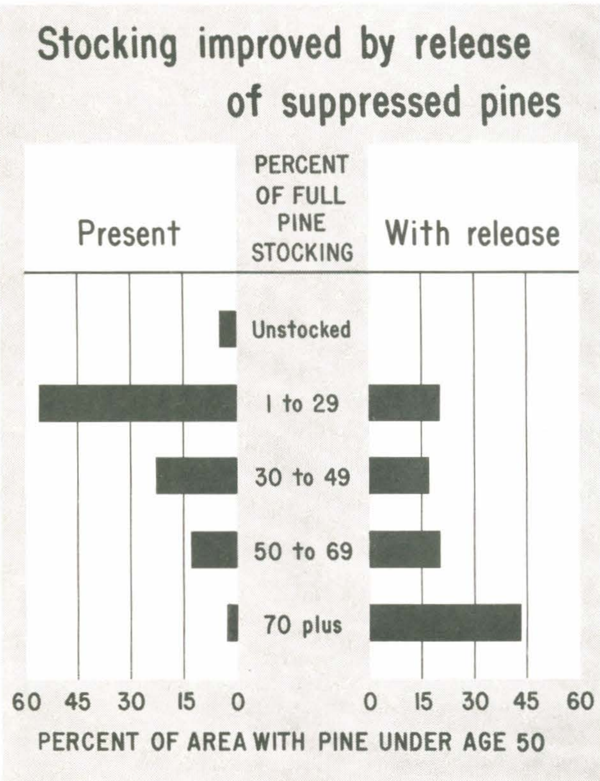

Figure 5

Young Pine Stands Predominate

Timber stands in which the white pines average less than 30 years of age occupy 765,000 acres, almost two-thirds of the total white pine area (fig. 6). Stands with pine less than 50 years old aggregate 891,000 acres. About one-fourth of the white pine area, 355,000 acres, supports stands with pine 50 years and older (table 3).

Young pine stands are most prevalent in the lower peninsula of Michigan. Stands less than 50 years old occupy three-fourths of the total pine area in central and southern Wisconsin and more than 80 percent in both Upper and Lower Michigan (table 4). In northern Minnesota, however, stands 50 years and older occupy almost two-thirds of the pine area. Here many poletimber stands that were protected from blister rust by Civilian Conservation Corps crews during the 1930's have grown into sawtimber stands that will mature satisfactorily with no additional treatment for blister rust control.

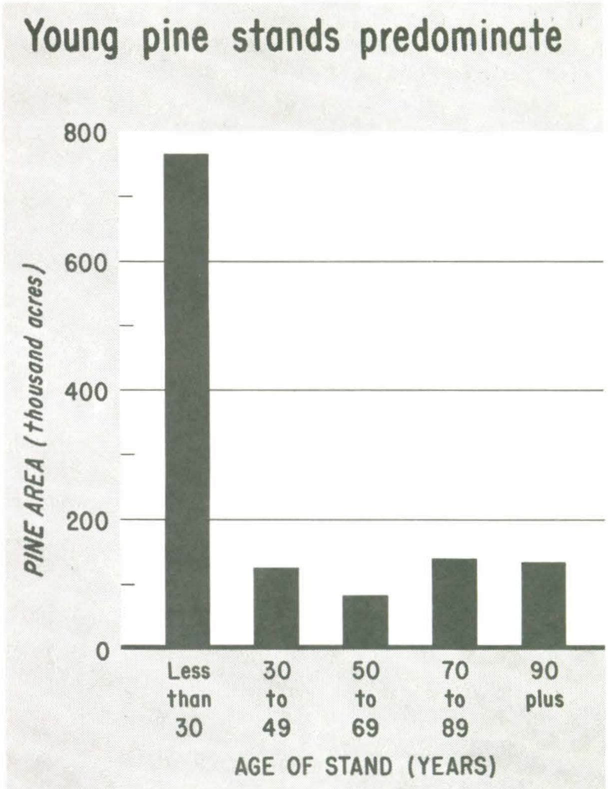

Figure 6

Potential Yield High on Productive Sites

White pine is capable of producing a greater volume of wood per acre on good sites than any other associated species. Once rapid height growth begins, generally at about age 10 to 15, white pine grows faster and maintains rapid growth for a longer period of years than its associates. Extensive stands containing 25,000 to 50,000 board feet of white pine per acre were formerly quite common. Yields of fully stocked stands on the best sites can be as high as 85,000 board feet per acre in 120 years.

The volume of timber that can be grown on any area depends greatly on the pro-

ductivity of the site. The productivity of a forest site is generally expressed in terms of site index, an age-height relationship, or the height that dominant and codominant trees will reach on the site at age 50 years. A stand of white pine on a site 70 can produce two to three times the volume of a similar stand on a site 50, depending on the length of rotation (the age of stand when harvested). Yields of fully stocked white pine stands for the range of sites in the Lake States, and for three rotation ages, are indicated in figure 7.

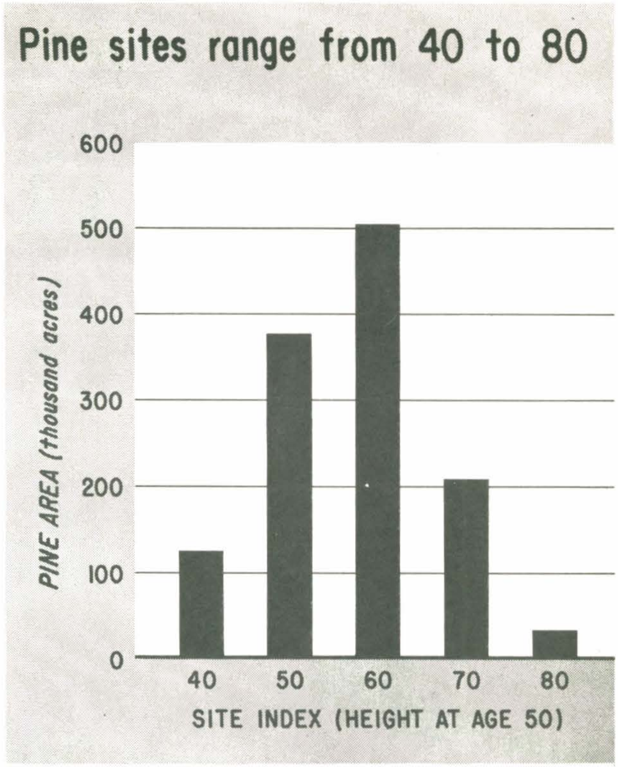

Figure 8

Good Sites Are Most Prevalent in the South

White pine site indexes in the Lake States range from 40 to 80. Sites 40 and 50 make up two-fifths of the total pine area. Sixty percent is site 60 or better. Only 3 percent is site 80 (fig. 8 and table 5).

Good sites are most prevalent in southern Wisconsin where sites 60 to 80 make up 90 percent of white pine area (fig. 9 and table 6). Depth and fertility of the soil and climatic conditions are less favorable in the northern part of the region. In northern Minnesota, more than 80 percent of the pine area is of sites 40 and 50.

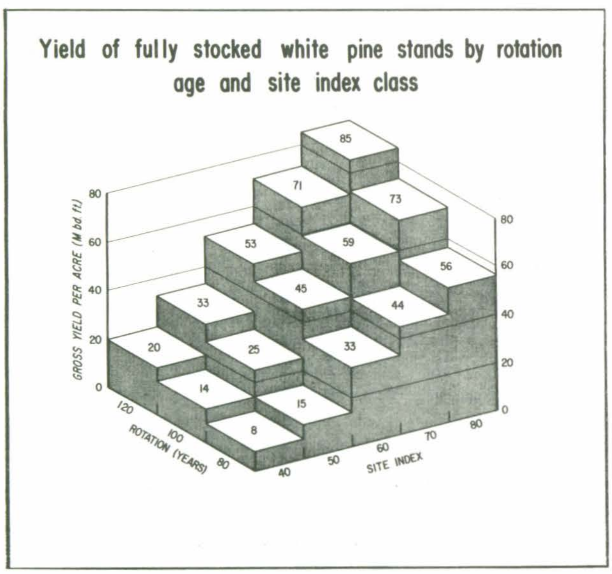

Figure 7

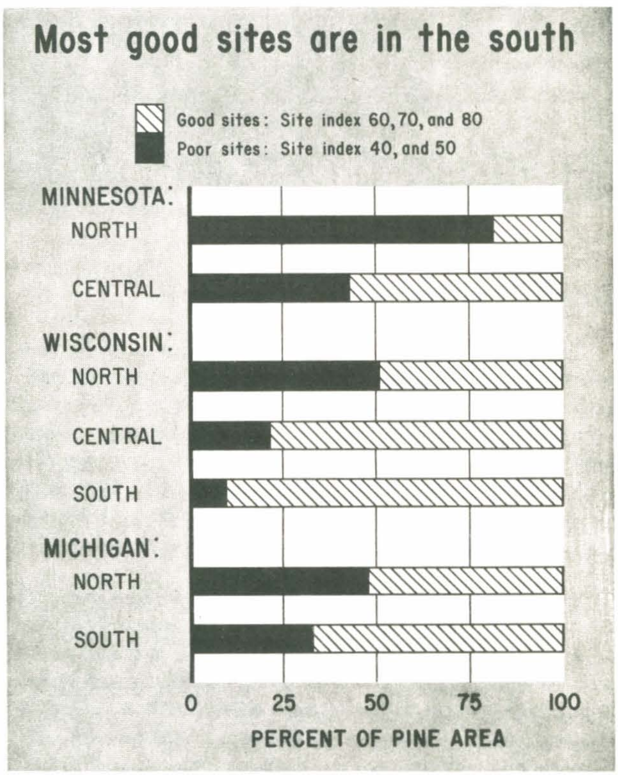

Figure 9

White Pine Sawtimber Volume Exceeds 3 Billion Board Feet

The present gross volume of white pine sawtimber in the Lake States totals 3.4 billion board feet. About 0.5 billion board feet, 13 percent of the total, occurs as scattered sawtimber trees on areas primarily occupied by other species or by white pine sapling and poletimber stands less than 50 years of age (table 8).

Stands 50 years and older contain about 3 billion board feet of white pine sawtimber (table 9). About 95 percent is in stands averaging at least 3,000 board feet per acre, 87 percent in stands exceeding 5,000 feet, 64 percent in stands exceeding 10,000 feet, and 34 percent in stands of 20,000 board feet or more per acre.

More than half of the 355,000 acres with pine stands 50 years and older contains at least 5,000 board feet of pine sawtimber per acre, and three-fourths of that area averages 3,000 or more.

Ownership Divided Among Many Individuals and Agencies

The white pine resource is owned by a variety of landowners. Fifty percent of the forest area occupied by white pine stands is owned by private landowners, mostly in small tracts; 14 percent is in national forests; 7 percent is in Indian reservations; and the remaining 29 percent is controlled by States, counties, and other local governments. Approximately 10,000 private landowners are involved, as well as a large number of public land-managing agencies. Thus ownership and responsibility for management of this white pine resource is distributed among many individuals and groups.

PROTECTION AND MANAGEMENT CAN INCREASE PINE YIELDS

The preceding section described the size and general condition of the present white pine resource. But the value of future yields from this resource depends upon current and prospective management as well as present conditions. This report deals with these managerial opportunities--specifically, with the opportunities for increasing the value of future white pine yields by blister rust control. In this section we describe the factors that determine the cost of controlling blister rust in various stands, and the volume and quality of white pine that will be saved thereby.

Rust Control Reduces Pine Mortality

White pine blister rust kills more white pine than any other disease. Blister rust is a parasitic fungus (Cronartium ribicola, Fischer) which exists during part of its life on white pine trees, and part on plants of the genus Ribes, commonly known as gooseberries and currants (10).[2] It spreads by means of airborne spores produced throughout the growing season and especially during cool fall weather. The disease cannot spread directly from one pine to another, but must alternate between ribes and pine. Blister rust, therefore, can be controlled by destroying all ribes plants within infecting distance of the pine, thus breaking the life cycle of the disease.

Losses vary by hazard zone.--Rust hazard and incidence of fatal rust infection on pines are greatest in the north and diminish southward. For this analysis, the Lake States region was divided into three general zones of high, medium and low hazard (fig. 10) on the basis of variations in rust hazard recognized by the Branch of Forest Pest Control, with adustments indicated by the results of a special rust-incidence survey (described in Appendix, page A-1) which provided the following data regarding rust-caused pine losses.

Within each of these general hazard zones, rust infection incidence varies considerably among localities because of a number of factors including direction and velocity of wind, amount of rainfall, density of forest cover, elevation, species, height and distribution of ribes, temperature, topography, and prevalence of fog. Research is underway to determine the relationships between rust hazard and such local conditions so as to make possible more precise determinations of the degree of hazard in local areas, and thus the thoroughness with which ribes must be eliminated. Lack of such precise information made necessary development and use in this analysis of average estimates of pine losses caused by rust that can be applied generally to each zone.

[2] Figures in parentheses refer to Literature Cited.

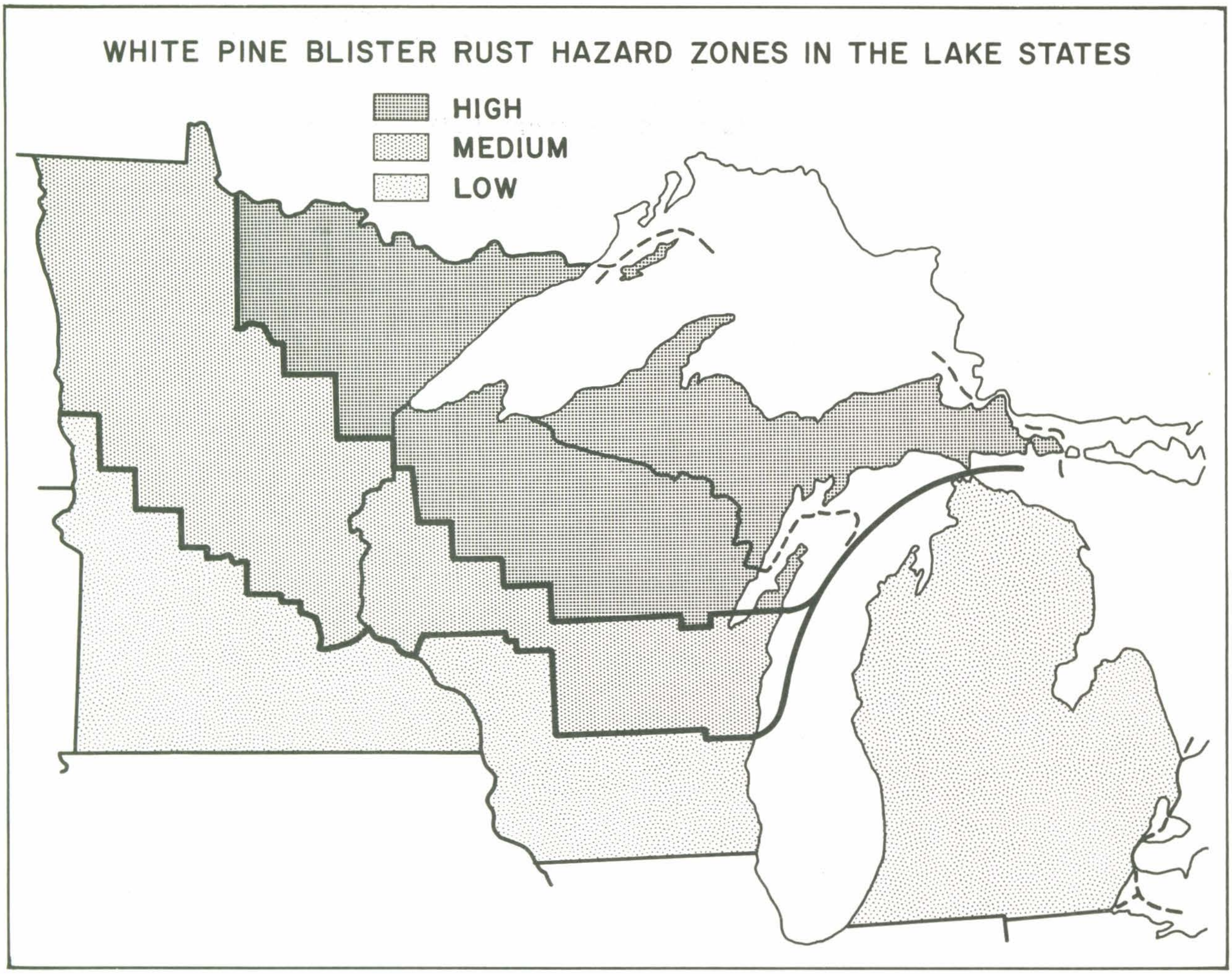

Figure 10

The proportions of pine fatally infected by blister rust in unprotected Lake States stands were determined for a 5-year period which included both wet and dry years. The proportions fatally infected annually in the high, medium, and low hazard zones averaged 1.26, 0.56, and 0.12 percent of the remaining healthy pines each year. These rates held constant for pines of all sizes and were not significantly affected by variations in density of pine or in ribes populations as they occur in the Lake States (6).

In some stands with well-spaced and heavy pine stocking, rust-caused losses as great as are indicated for the high hazard zone might not be serious, and occasionally might even provide beneficial thinning. Unfortunately, however, white pine stands in the Lake States generally are not heavily stocked. Only one-sixth of the pine area with stands less than 50 years old supports stands exceeding half of full stocking. Therefore, in this analysis where only well-spaced dominant and codominant pines are included in stocking estimates, all pine losses caused by rust are considered real losses.

Although these annual infection rates seem small, they cause sizable losses of pine during a stand rotation. In the high hazard zone, for example, loss of 1.26 percent of the remaining healthy pines each year throughout a 100-year rotation would leave only 29 percent of the yield expected at harvest time if it were unaffected by rust losses. However, some trees killed by rust after reaching merchantable size could be salvaged. Furthermore, pines infected after reaching sawtimber size generally continue to live and grow for long periods before dying. More than 20 years often elapse between initial infections and fatal girdling of sawtimber-size pines. In this analysis, therefore, infections originating in sawtimber-size pines during the last 20 years before harvest are assumed to cause no losses.

By applying annual rates of fatal rust infection throughout all but the last 20 years of different length rotations, we computed proportions of various pine harvest volumes that could be saved by rust control. In the high hazard zone with a stand on a 100-year rotation, for example, establishment of rust control by stand age 10 will save 57 percent of the harvest volume expected with no rust losses. Estimated proportions of expected pine yields that can be saved by blister rust control in each rust hazard zone with various intervals between establishment of control and harvest are shown in figure 11.

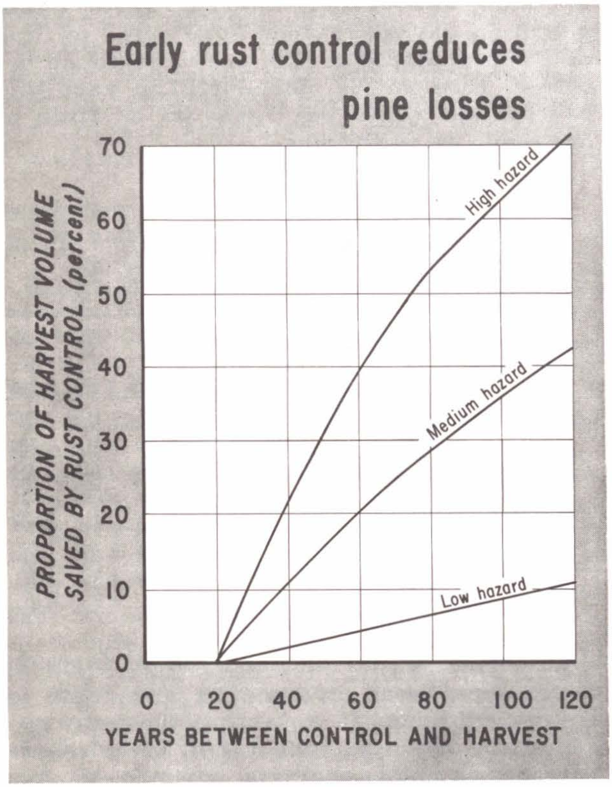

Figure 11

Figure 12.--Blister rust can be controlled by destroying currant and gooseberry bushes within infecting distance of the pine. (Minn. Conserv. Dept. photo)

Blister rust can be controlled.--Today most control work is done by digging or pulling ribes bushes by hand (fig. 12), or by chemical spraying in problem areas where the bushes are too difficult or costly to dig. Effective control is obtained by destroying ribes bushes growing in white pine stands and in protective zones surrounding them. The width of the protective strip required in the Lake States generally varies from 500 to 1,000 feet depending on climatic conditions, elevation, latitude, density of cover, and the species of ribes.

Maintaining overstory cover can sometimes help to hold ribes population at low levels in white pine stands and reduce losses. Diseased pines often can be saved by pruning off infected branches. Another long-term approach to control, on which considerable progress has been made during the past decade, is selection and breeding of pines resistant to the rust.

Still another promising possibility is use of antibiotics, such as Acti-dione and Phytoactin. Incomplete tests on western white pines indicate that these antibiotics sprayed on infected pines can kill the rust fungus. A practical method of curing rust infections following moist years which produce conditions bringing about high rates of infection could make costly eradication of ribes unnecessary. In initial tests, the reactions of eastern white and western white pine to antibiotics have differed. Additional research is being done by the Forest Service to determine the potentialities of this promising means of control.

Control costs vary among stands.--Current rust control costs per acre vary considerably among stands depending upon factors such as the density and distribution of ribes, the nature of the ground and vegetative cover, and the extent of disturbance to the stand by logging and similar activities. Costs per acre of white pine area also vary with the size of the pine stand, because of the need for eradication of ribes on an isolation or protective strip surrounding each area of pine.

On some areas only a single treatment is needed, many areas require two, and a few areas require three or more to establish control which can be maintained thereafter by occasional maintenance checks. Generally about 6 years are allowed to elapse between successive workings. This period provides time for new ribes bushes from seed or from sprouts of bushes pulled in the initial working to develop and become readily visible, but not sufficient time for them to mature and bear seed. The amount of field manpower required for each ribes eradication treatment ranges from less than 0.1 to more than 3 man-days per acre of pine area in the Lake States, and currently averages about 0.15 man-day per acre.

The cost per man-day of ribes eradication work used in this analysis was $28 (1957 dollars), and was based on Forest Service Region 9 records of 1957 rust control operations in the Lake States. It was compiled by dividing total regional expenditures for all rust control activities by the number of man-days spent in actual ribes eradication. Thus it included costs of supervision, equipment, and other overhead expenses as well as of field labor.

In appraising investment opportunities, allowance for unpredictable risk is customarily made by reducing expected returns. In this study allowance for risk was handled in a sense as an insurance premium added to costs. To the basic cost of $28 per man-day, a 25-percent risk factor was therefore added, making the total cost per man-day $35.

On control operations requiring more than one treatment, each successive working requires about half the amount of field labor needed to complete the preceding working, according to R-9 records. Since 6-year intervals are allowed between workings, control costs will be incurred over a period of years and must be placed on a comparable basis by use of customary discount procedures. It was accordingly assumed that the initial working would occur during the year of analysis, and the cost of subsequent workings was discounted to that year using a risk-free compound interest rate of $2\frac{1}{2}$ percent. The cost per man-day of all future rust control treatments discounted to the time of initial working was thus calculated to be:

	Cost per man-day
One working	$35.00
Two workings	33.39
Three workings	32.34
Four workings	31.67

For comparisons with value of pine saved at time of harvest, these control costs per man-day were then projected to time of harvest using a risk-free compound interest rate of $2\frac{1}{2}$ percent. The resulting capitalized costs per man-day at time of harvest are as follows:

Number of years between 1st working and harvest	*Cost per man-day according to number of future workings--*			
	1	2	3	4
31 - 40	$83	$79	$77	$75
41 - 50	106	101	98	96
51 - 60	136	130	126	123
61 - 70	174	166	161	158
71 - 80	223	213	206	202
81 - 90	285	272	264	258
91 - 100	365	349	338	331
101 - 110	467	446	432	423
111 - 120	599	571	553	542

Selection of the proper rate of interest for comparisons of benefits and costs is always difficult. In selecting the rate appropriate for the long-term investments considered in this analysis, procedures used by the Federal Inter-Agency River Basin Committee for economic analyses of river basin projects were considered as a guide. This group recommended that the expected average long-term government bond rate be used as the basis for calculating Federal or non-Federal public investment costs (3). In early 1958, when computations for this analysis were started, the rate on river basin project investments used by member agencies of the Federal Inter-Agency River Basin Committee was 2.5 percent. This rate also was used by Vaux in his analysis of the economics of blister rust control and other management practices in sugar pine,

results of which were published in 1954 (18).[3] Accordingly a risk-free and inflation-free interest rate of 2.5 percent was used in this analysis.

In view of recent trends in interest rates, a higher rate might appear to be more appropriate. But higher rates of return in recent years have been due in some measure to inflation. And in this analysis the estimates of future income were based on 1958 dollars. A 2.5 percent return in these terms is equivalent to a much higher rate measured in terms of the anticipated inflation that is reflected in current interest rates. This analysis could have been based either on higher interest rates and estimates of future income considering inflation, or on inflation-free interest rates and constant dollar values. The latter was selected. However, costs per man-day at both 3 and 3.5 percent interest are presented in table 10 for use, if preferred.

Benefits From Rust Control Depend on Stand Conditions and Other Management

Rust control saves many white pine trees from being killed by blister rust. But the eventual volume and value of the trees that are saved depend not only on stand conditions--such as the number and vigor of pine trees present--but also on the future management of the stand, for example, on the size of the trees when they are cut and whether they will be pruned and thinned.

Thus the remainder of this chapter will discuss the effect of other management practices on the volume and value of the pine crop at harvest. The costs of applying these other management practices will not be discussed, however, for these costs are not directly needed in this analysis of public rust-control programs on land that is largely in private ownership. These costs are not relevant because decisions concerning the actual adoption of these practices cannot be made by the rust control agency. Indeed, usually the only decision the rust control agency can make is whether or not to control rust in a given stand. And even though their careful analysis might indicate that thinning and pruning, for example, might be extremely profitable in a given stand, the rust control agency can do little about it. The decision to thin and prune is not theirs: it is the landowner's.

[3] Results of another earlier study by D. N. Mathews and S. B. Hutchison to help guide blister rust control activities in the Northern Rocky Mountain Region were published in 1948: Development of a Blister Rust Control Policy for the National Forests in the Inland Empire. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta., Sta. Paper 16, 116 pp., illus.

But even more important, the profitability of rust control is not determined by whether or not other measures are profitable, but rather, by whether or not the other measures will indeed be practiced. Actual management will determine the profitability of public rust control investments on private land. And because different people and hence different concepts of value, different financial opportunities, and different costs are involved, owners often adopt practices that differ from those resulting from calculations of profitability.

Therefore, public rust-control funds will yield the greatest returns if they are spent in those stands where the estimated value of white pine saved (considering probable management) is greatest relative to the cost of control. And this is the method of analysis we have used.

Weevil Control Increases Quality and Volume of Pine

The white-pine weevil (Pissodes strobi (Peck)) causes more damage to white pine trees than any other insect. It attacks and kills the terminal shoots, sometimes affecting the past 2 or even 3 years' growth. Trees seldom are killed by the weevil, but loss of the terminal shoot causes lateral branches from the highest living whorl to turn upward as new terminals. This generally results in crooked tree boles and frequently in multiple-stemmed, deformed trees (fig. 13). Weevil attack generally causes loss in pine volume and quality, and repeated attacks sometimes render a tree worthless for forest products.

Weevil attack greatest in the south.--The incidence of weevil attack in white pine was found to be twice as great in the southern part of the region as farther north. In the high and medium rust-hazard zones, according to data gathered in connection with the rust-incidence survey, one-third of all butt logs showed evidence of weevil damage compared with two-thirds in the southern low rust-hazard zone. The proportions weeviled once, twice, and up to five or more times in the south averaged in each case about double the proportions farther north (fig. 14). This is believed primarily due to differences in forest cover. The pine area in the south includes more relatively open pine stands that that in the north, and open-grown pine, as indicated below, generally receives more weevil damage than understory pine.

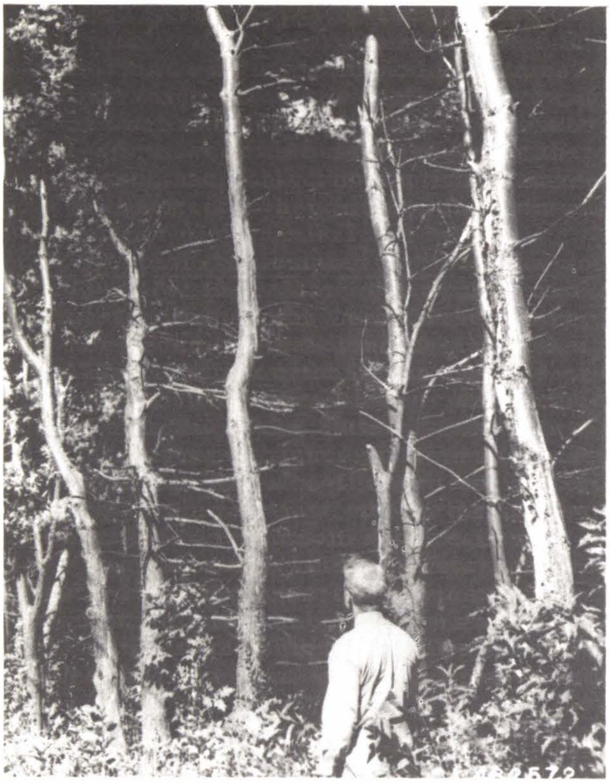

Figure 13.--White-pine weevil attack generally results in crooked pine boles and often in multiple-stemmed, deformed trees. (F-482572)

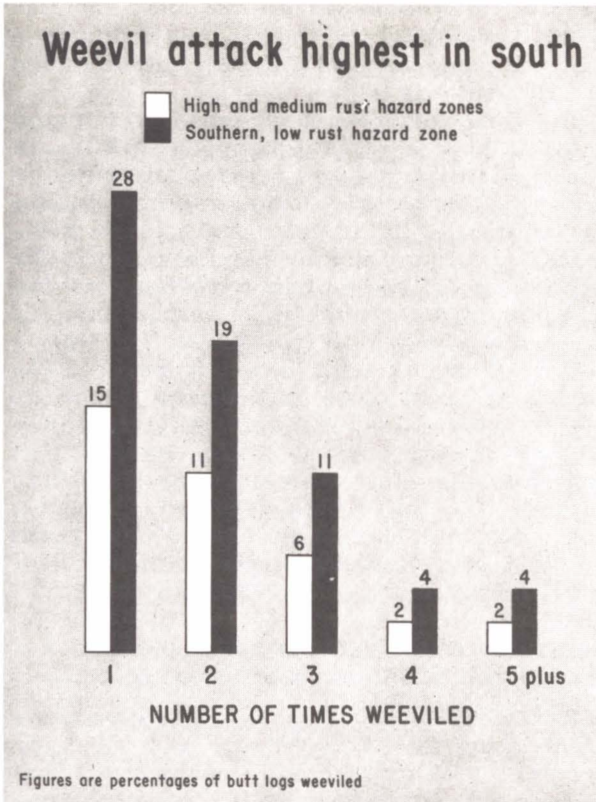

Figure 14

The above findings were supported by results of another completely independent survey made a year later on different sample areas. Data on incidence of weevil attack were also gathered in the site-stocking survey. Results showed that in natural pine stands, the number of weevil injuries per foot of pine bole average 0.029 regionwide (1 injury in each 34 feet) with 0.022 in the high and medium rust-hazard zones compared with 0.044 (double the northern rate) in the southern low rust-hazard zone. In white pine plantations, however, weevil injuries per foot of pine bole are essentially the same in both areas, and average 0.091 per foot of bole (1 injury in each 11 feet) throughout the region.

Weevil control possible by several methods.--The characteristics of weevil attack make possible reduction in weevil damage by silvicultural measures. Weevil damage is most severe in pure, even-aged white pine stands, such as plantations or stands that have seeded in on old fields. Damage is less severe in dense stands than in those with light stocking, because more trees remain free from attack and those damaged recover with less deformity. Generally weevil damage is least where white pine is grown under a protective overstory of hardwoods. Thus the damage caused by the white-pine weevil can be reduced by maintaining overstory cover, although with some sacrifice of pine growth. Crowded or overtopped pines do not grow as rapidly as free-growing trees.

Methods of weevil control which permit release of pine from growth-retarding competition are being developed. Research technicians are now exploring biological controls and new effective insecticides, including methods of application for use in both ground and aerial spraying. A number of insecticides including lead arsenate, DDT, lindane, heptachlor, and malathion sprays and emulsions have been tested with excellent results. While aerial spraying techniques and biological controls are still to be developed, effective insecticides and methods of spraying pine terminals from the ground are already available. For example, in replicated tests under heavy weevil populations, spraying a lindane emulsion including an extender on white pine terminals from the ground resulted in only one weeviled terminal out of 10,000 pines sprayed (2).

For this analysis, pine losses caused by weevil attack were estimated for the full range of stand conditions in the Lake States, with and without weevil control. It was assumed that weevil damage would be controlled by insecticides sprayed from the ground, and that control is applicable only in the next 16 feet of height growth of pines now less than 20 feet tall.

Weevil losses calculated by formula.--Procedures for estimating pine volume and quality losses caused by weevil injury were developed in the Northeastern Region of the United States with northeastern data as a basis. These procedures are considered applicable in the Lake States, since entomologists with experience in both regions generally agree that weevil characteristics and problems are much the same under similar stand conditions in both regions.

In a special study in southeastern New Hampshire (8), a regression of volume loss on tree size and number and position of weevil injuries was calculated. The following formula was developed for predicting volume loss:

> Volume loss per acre in board feet = 2.08 X (number of trees at harvest) X (average d.b.h. at harvest - 8.0") X (average number of weevil injuries per foot of pine bole) X (merchantable-length factor).

The number of trees and average d.b.h. at time of harvest depend on the stocking of pines in the present stand, site index, rotation age, and whether or not thinnings will be made. This information was obtained directly from white pine yield tables prepared by the Lake States Forest Experiment Station[4] and is summarized in table 11. Tree size is expressed as d.b.h. minus 8 inches because volume tables used show no board-foot volume in trees less than 9 inches d.b.h.

Average number of weevil injuries per foot of pine bole is used as an indication of the future rate of weevil attack in any pine stand. Ostrander found that the weevil-injury rate does not vary with tree height and is relatively constant throughout the merchantable length of white pine (11). The injury rate that has already occurred, as determined on sample field plots, is therefore used as the best estimate of future rate of attack in any established white pine stand.

[4] Data on which Wisconsin Agr. Expt. Sta. Res. Bul. 98 (4) was based were used to develop yield tables for partially stocked stands keyed to current merchantability standards; these covered a broader range of site indexes than were included in Bul. 98.

The merchantable-length factor is used in a weighting system devised to account for differences in volume loss due to weevil injuries at different heights in a tree. In trees of a given size, an injury in the bottom log causes greater volume loss than one in the second or third log. As rotations become longer and harvested trees larger, however, lower log injuries become relatively less important than in small trees. The number of injuries in each tree, therefore, was expressed in terms of butt-log injuries by giving injuries in the first log a weight of 1, those in the second log a weight of 1/2, the third log 1/3, etc. For any given number of logs, the factor is a constant. In a three-and-a-half log tree, for example, the factor is 16/1 + 16/2 + 16/3 + 8/4 = 31.3 (table 12). The number of logs or merchantable height of a tree at time of harvest depends on site index, rotation age, present pine stocking, and whether or not thinnings will be made. Average merchantable length for each stand condition is presented in table 11.

Merchantable-length factors depend on the merchantable length that will be subject to weevil injury. With no weevil control planned, the merchantable-length factor is used directly from table 12. With weevil control, however, the protected portion of merchantable length will not be subject to injury, and only the factor applicable to the remaining portion of merchantable length is used. The factor to be used with weevil control anticipated is derived by subtracting the factor for the protected portion of the bole from the total factor for the tree. Without control, for example, the factor for a 3-log tree (48 feet of merchantable length) is 29.3 (table 12). With weevil control during growth of the first 16-foot log, the factor for the tree becomes 29.3 - 16.0 = 13.3. For simplicity in this analysis, however, we assumed an average situation based on the tree size of existing Lake States stands and existing control methods. In any protected stand, control of weevil was assumed throughout development of one 16-foot log between 13 and 29 feet of tree height. The merchantable-length factor for this 16-foot section was subtracted from the total merchantable-length factor of the average tree at harvest to derive the factor applicable in a protected stand.

Thus the volume of weevil loss with or without weevil control can be estimated for any combination of site, stand, and management conditions.

Timber quality also reduced by weevil.--
In white pine timber weevil damage also causes lumber degrade due to defects, such as cross grain, large branch knots, loose knots, red rot, and compression wood.

In a sample of 400 white pine logs studied in New York, weevil-caused losses in lumber value ranged from $2 to $34 per thousand board feet, at 1956 wholesale prices (12). According to this study, the value of a log can generally be reduced $5 per thousand board feet for the first observed weevil injury plus $2 per thousand board feet for each additional injury. In stands where stumpage is selling for $25 per thousand board feet, a potential loss or gain of $7 per thousand (two injuries per log) is relatively large.

The quality of pine timber and the effects of weevil damage on timber quality vary considerably with stand conditions and type of management used in any stand. Procedures used to estimate quantitatively the effects of weevil on pine quality for specific conditions in individual stands are discussed in detail in a later section of this report (page 18).

Release Increases Pine Stocking

The growth and development of white pine is strongly influenced by (a) the species composition of the stand and (b) how the stand is managed. If white pine is to be favored in a mixed stand, release often is required. White pine is intermediate in tolerance to shade and has surprising ability to persist under a canopy. On poor sites, particularly under thin canopies of oak or aspen, white pines often develop satisfactorily and break into dominance at a relatively young age. On good sites, however, strong competition often develops early and many small pines never reach the sapling stage. Until they are 6 to 8 feet tall, white pines on good sites usually are unable to keep ahead of competing hardwoods, and if release is delayed until this time, many pines die.

Fortunately, white pine is tolerant to the herbicide 2,4,5-T and moderately tolerant to 2,4-D after the period of most active seasonal growth is past (1). These chemicals, applied by either aerial or ground treatments, can kill back and inhibit sprouting of competing hardwoods and thus provide effective release (fig. 15). Further-

Figure 15.--Silvicides applied in either aerial or ground treatments can kill and inhibit sprouting of competing hardwoods, thus effectively releasing suppressed white pine. (F-478620)

more, white pine responds well to release, although pines that have been badly suppressed might require 5 to 10 years in which to rebuild their crowns before showing much diameter-growth response. Pines that have not been badly suppressed, however, generally will respond to release within a year or two. Because of its rapid height growth after the juvenile period, and its long life, white pine will ultimately dominate any of its associate species if given a reasonable amount of growing space during its juvenile years.

Stocking conditions and the need for release treatment in Lake States white pine stands were appraised in the regional site-stocking survey. In this analysis stands 50 years old or more were considered too old for effective release treatment for the following reasons: Most of these older stands contain few suppressed young pines because of the density of canopy. Where suppressed understory pines do exist in these older stands, they usually have little change of developing satisfactorily until the saw-timber overstory is removed by logging. Release of pines under such conditions is impractical because of the severity of cut that would be required in most cases. Release treatment, therefore, was considered applicable only in stands less than 50 years old.

More than four-fifths of the 891,000 acres with white pine stands less than 50 years old contain some suppressed young pines in need of release. Almost half the total area, or 392,000 acres, contains at least 50 well-spaced suppressed pines per acre which could be added to the pine growing stock by release.

The need for release is greatest in the southern, low rust-hazard zone where good sites are most prevalent and hardwood competition most severe, and least in northern Minnesota where poor sites predominate. The primary type of competition in stands with at least 50 suppressed pines per acre in need of release consists of hardwood on 75 percent of the area, red pines on 11 percent mostly in the north, and other conifers, primarily balsam fir, spruce, and hemlock, on the remaining 14 percent (table 13)

Release of white pine on all 392,000 acres with 50 or more suppressed pines per acre is not recommended. Release of small white pine is impractical where it involves killing thrifty larger red pines or high-quality hardwoods. Exclusion of the 90,000 thousand acres where such species are the primary type of competition (table 13) would reduce the area with 50 or more pines per acre in need of release to about 300,000 acres. In each individual stand the decision on management alternatives and species to be favored must be made by the local forest manager with overall management objectives in mind.

Thinning and Pruning Increase Size and Quality of Trees

Thinning produces larger trees of higher quality.--Many stands contain sufficient stocking to benefit by one or more thinnings before the final harvest. Thinning provides more growing space for the trees remaining and results in fewer but larger trees in the final harvest. Besides, the most undesirable trees generally are removed in thinning operations, and this further improves the quality of the remaining stand. Alternative methods of thinning can be used depending upon site, stand conditions, funds available, and owner objectives. For the present analysis, only one method was considered.

The volume of thinnings that can be removed in intermediate cuttings was determined by computing the potential volume at rotation age in thinned and unthinned stands. This involved three general steps for each stand condition: (1) Cutting back to the optimum stocking level as soon as the stand volume exceeds this level (the optimum stocking levels were those used in computing the white pine allowable cut in the Lake States Forest Survey); (2) estimating growth during the next 10 years by use of Gehrhardt's formula;[5] and (3) repeating the above steps for each 10-year interval up to rotation age. The volume of thinnings for any stand condition is the difference between thinned and unthinned final harvest volumes thus computed. These are shown in table 11. The effect of thinning on the quality of the remaining stand is discussed in a later section (page 19).

Pruning greatly improves pine quality.--Pruning of lower branches can improve the quality of lumber produced from most trees by reducing the size and number of knots. Pruning is especially needed in growing quality white pine. On eastern white pine dead limbs often are retained for 50 years

[5]Growth during the period = dg(1 + k - kd); where d = percent of normal stocking, g = normal growth during period, and k = Gehrhardt's constant (relative tolerance) = 0.9 in this case.

or more. This causes undesirable knots which lower the quality of lumber produced. Early crown closure and high stand density tend to kill and eliminate lower branches. In dense stands, branches also are shed sooner because of crown friction. Although such factors help to control knottiness, the most certain way to attain quality lumber from white pine in a reasonable time is by artificial pruning (fig. 16).

In stands where pruning was anticipated in this analysis, it was assumed that up to 100 potential final crop trees per acre would be pruned to 17 feet in height by the time the pines average 6 inches d.b.h. Also, if more than 100 crop trees were available per acre, well-spaced pines with the best form and growth would be chosen for pruning, and no pruned trees would be removed in thinnings. The effect of pruning on the quality of pine in the final harvest is discussed in the following section.

Quality of Trees Expressed by an Index

The quality of white pine largely determines pine value and therefore must be considered in appraising the profitability of blister rust control. Differences in the quality of pine produced with various stand conditions and treatments were expressed, in this analysis, in terms of a quality index. First, a base quality index was established as the average quality index of unthinned, unpruned, and unweeviled white pine now being harvested from New England stands. Adjustments in the base quality index were then determined for predicted changes in quality likely to occur under each stand condition from weevil damage with and without control and from thinning and pruning.

Quality index reflects both value and proportions of different grades of lumber in the tree. It is computed by multiplying the percent of total volume in each grade by the price relative for that grade, and adding the resulting products. The price relatives used in this study were average grade prices for 1953-55 expressed as a percent of the average wholesale price of #1 and #2 Common white pine lumber as quoted in the Boston Commercial Bulletin. The average wholesale price of #4 and #5 Common white pine lumber is about half, and of #3 Common about three-fourths, that of #1 and #2 Common lumber. The price of D and Better Selects is $1\frac{1}{2}$ times that of #1 and #2 Common white pine lumber.

Figure 16.--Pruning persistent lower branches is especially needed in growing quality white pine.

The estimate of future quality index assumes that this relationship in prices among grades will remain unchanged.

Thus determined, the average quality index of white pine now being harvested in New England is 67. Almost all of this pine is being harvested from unthinned, unpruned stands.

Adjustments made for weevil injury.--Data from the weevil damage study in New Hampshire (8) indicates that approximately 4 index points (as calculated below) were lost because of weevil injuries. If the pine now being cut had not been weeviled, the average quality index would be 71. Thus the base quality index for unweeviled, unthinned, and unpruned white pine stands used in this study is 71.

Adjustments in the base quality index for weevil injury depend on the frequency of weevil attack. An analysis of the log grade data taken at the Pack Forest, New York (12) indicates that each weevil injury per foot of pine bole causes a decrease of 35.2 quality index points. For example, if the

quality index of an unweeviled tree is 82 and weevil injuries average 1 in every 10 feet, the quality index would be 82 - 35.2 (0.1) = 78. With weevil control, an adjustment for the protected volume was made, and the following formula was developed for computing quality index loss due to weevil injury:

$$\text{QI loss} = 35.2 \text{ (number of injuries per foot of bole) (percent of tree volume unprotected)}$$

The percent of tree volume unprotected was calculated for all combinations of site, stocking, and rotation age. As in the volume loss calculations, weevil control was again assumed applicable only in the next 16 feet of height growth of pines now less than 20 feet tall. For simplicity, we assumed an average situation based on the size of existing Lake States stands and existing control methods. For each combination of conditions, the volume in the 16-foot log between 13 and 29 feet in tree height was subtracted from total tree volume, and this was divided by total tree volume to obtain percent of tree volume unprotected.

Adjustments made for thinning and pruning.--Thinnings remove the poorest quality material in the stand and thus raise the quality index of the final harvest volume. Accordingly, the quality index of the harvest volume for each combination of stand condition and treatment was increased five index points in thinned stands.

Pruning can greatly increase the quality of the final harvest. Where pruning is anticipated, we assumed that the first log of up to 100 pines per acre would be pruned before the trees reach 6 inches d.b.h. Two additional inches of diameter growth were allowed to enclose the knotty core, resulting in a central core with a 7-inch scaling diameter containing all knot defects in the first log. We also assumed that all material outside this knotty core would be manufactured into Select lumber. About 2 percent of the second-growth white pine currently being cut in New England is of Select grade. The volume in unpruned trees was assumed to be 20 percent #1 and #2, Common, 40 percent #3 Common and 40 percent #4 and #5 Common, and the increase in quality index due to pruning was computed for each site and stand condition as shown in table 14. This increase varied from 10 to 28 points.

Management Treatments Not Applicable in Many Stands

The above management treatments are not needed in many Lake States white pine stands. Weevil control, for example, accomplishes nothing in stands where no weevil damage is occurring. Further, pines more than 20 feet in height are considered too tall for application of present weevil control measures; and the butt logs, the most valuable portion of the trees, have already suffered all of the damage weevil can inflict. Under the assumptions used in this study, weevil control is applicable on 450,000 acres, about half of the area with stands less than 50 years old (fig. 17 and table 15).

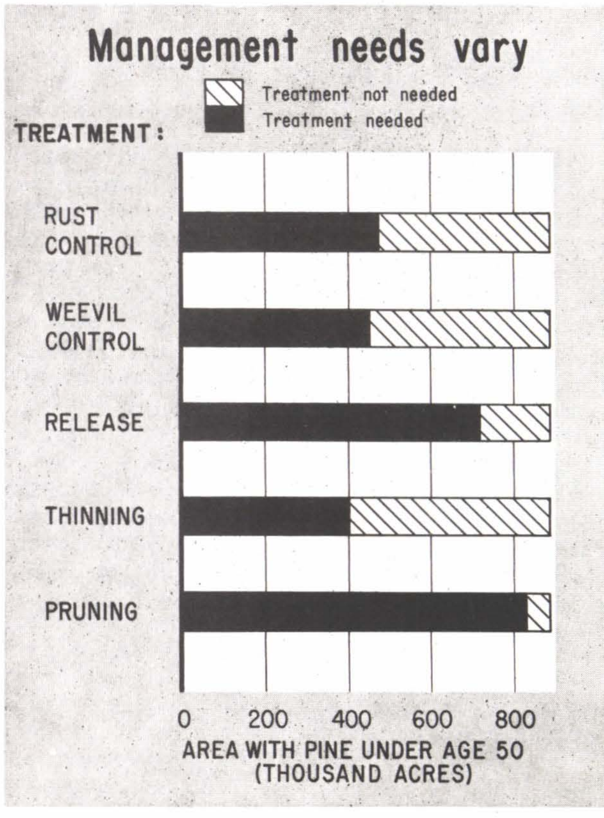

Figure 17

Similarly, release treatment is applicable only on areas that contain young suppressed pines in need of release--about 720,000 acres or 80 percent of the area with stands less than 50 years old. Almost 400,000 acres of this contain at least 50 suppressed pines per acre (table 13).

Thinning is applicable on about 400,000 acres with young stands of sufficient

density to support one or more intermediate cuts.

More than 800,000 acres, or 90 percent of the area with stands less than 50 years of age contains pines less than 6 inches d.b.h. that would benefit considerably from pruning.

FUTURE MARKETS AND VALUES FOR WHITE PINE

How profitable blister rust control will be in any stand and the area of white pine stands that can return benefits exceeding control costs depend on the value of pine saved by control measures as well as control costs. Prices paid for white pine at the time existing young stands are harvested will depend on future markets for products made from white pine. This section, therefore, considers what the future uses and values of eastern white pine products are likely to be.

White Pine Used Primarily as Lumber

Almost all eastern white pine harvested is converted into lumber (16). Although the pulping qualities of white pine are good, very little is used as pulpwood. Some white pine rotary-cut veneer is used in box production, and recently some sliced veneer has been used for knotty pine paneling. A small volume of short logs or bolts is cut directly into pieces used in making pails, tubs, and other specialty products without being first sawed into lumber. The volume of bolts thus used in 1948 totaled about 7 million board feet (9), less than 1 percent of the volume of eastern white pine harvested. Thus the eastern white pine markets and values which must be considered in this analysis can be limited to those of white pine lumber.

Decline in Consumption Attributed to Short Supply

Production of white pine lumber started in New York about 1630, increased steadily throughout the 19th century, and reached an all-time peak of 9.4 billion board feet in 1889 (16). More than 7 billion feet of this record production was cut in the three Lake States. Possibly one-third of the white pine production reported in the Lake States about 1900 was red pine sold in mixture with white pine as "northern pine." White pine production reported in recent years also includes small quantities of red and jack pine.

By 1909 production of eastern white pine had dropped to 3.7 billion board feet. Thereafter, production steadily declined to a low of 198 million in 1932. Since 1941 annual production has averaged about 1 billion board feet, with 848 million produced in 1956, the latest year on record (fig. 18).

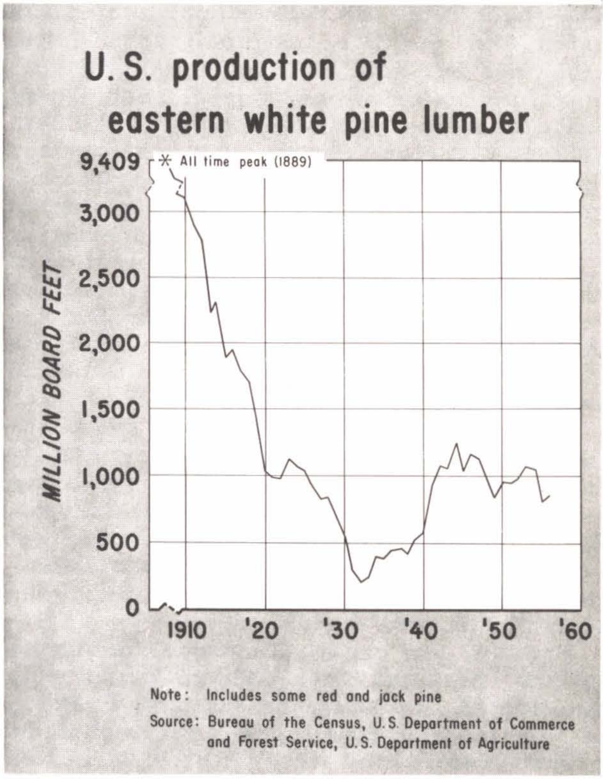

Figure 18

During the past decade New Hampshire, Maine, and New York have been the leading producers, with most of the saw logs coming from second-growth stands. Together they now produce about 60 percent of all eastern white pine lumber; the Lake States produce 15 to 20 percent, and about 20 other States contribute the remainder.

The tremendous consumption of eastern white pine in the past and its inherent qualities leave little doubt regarding its general desirability. Probably a substantial part of the future lumber market can be

recaptured by white pine as the supply increases with development of the young pine resources.

Uses of White Pine Lumber Depend on Quality

Eastern white pine lumber has three major uses. In 1948 about one-third was used in light construction for sheathing, subflooring, and other structural elements. Forty-five percent was used for packaging and crating. The remaining 22 percent was used to manufacture specialty products such as patterns and flasks, millwork, furniture and fixtures, boot and shoe findings, toys, athletic equipment, map and shade rollers, and wood novelties (9).

The proportions of white pine lumber used for different purposes depend to a considerable extent on the quality of the lumber available. For example, the lower grades are generally suitable only for construction and containers. About 80 percent of eastern white pine lumber cut in 1948 was used for construction and containers; about 85 percent of the lumber produced was of grades #3 Common and lower.

In contrast, manufactured specialty products require high quality lumber--the Select or high Common grades--or clean pieces cut from between defects in lower grade shop material. In 1948 production of #2 Common and higher grades amounted to about 150 million board feet compared with 220 million feet used for manufactured products.

White Pine Lumber Must Compete for Markets

Eastern white pine lumber must compete for markets with lumber made from other species and with a number of nonwood materials. The amount and type of competition depend on the use.

In construction the most important competitors are materials made of other softwood species, such as Douglas-fir and southern pine lumber, Douglas-fir plywood and various building boards, as well as nonwood products such as gypsum board. White pine has no great technical advantage over its competitors for construction uses, although in local markets it competes favorably.

For packaging and crating, the major competitors of white pine lumber are various types of container board, plywood and veneer, and southern softwood and local hardwood lumber.

In manufactured products white pine lumber competes with a number of nonwood materials, such as aluminum, steel, and plastics. Ponderosa pine, eastern white pine, western white pine, and sugar pine are the major species used in many manufactured products. The three soft pines, eastern white, western white, and sugar pine have similar technical properties including easy workability, dimensional stability, and softness. As a group these three species are close substitutes, and are clearly distinguishable from the hard pines (such as the southern pines), which have quite different properties. Old-growth ponderosa pine has many of the characteristics of the soft pines, such as softness and workability, and is substituted for white pine in some uses.

Competitive Position of Eastern White Pine Lumber Varies by Use

Relatively unimportant in construction.--During the 18th and 19th centuries a major portion of all lumber used in construction was cut from eastern white pine. As late as 1905 eastern white pine lumber production amounted to about 5 billion board feet annually, most of which was used for construction. With depletion of the great eastern pineries, Douglas-fir, southern pine, and ponderosa pine became the major species used for this purpose. White pine accounted for less than 5 percent of all softwood lumber used in construction since 1928.

White pine important for containers.--For containers, the white pines have held a more prominent position. During the two decades 1928-48 almost 20 percent of all softwood lumber used for containers was white pine, most of which was eastern white pine (14, 15, 7, 9). Nearly 3 billion board feet of softwood lumber was used for containers in 1948, including 976 million board feet of ponderosa pine, 449 million of eastern white pine, 24 million of sugar pine, and 18 million of western white pine (9).

Considerable substitution of various kinds of paperboard and wirebound veneer boxes and crates for containers made of lumber has occurred during the past three decades.

Such substitutes are cheaper and add less weight in shipment of goods than containers made of lumber. Nevertheless, containers made of lumber are still preferred for many uses. They are superior for shipping fresh fruits and vegetables, mainly because they provide better protection and are not weakened by moisture in refrigerator cars. Nailed lumber boxes and crates will continue to be used for shipment of manufactured products that require protection, in overseas shipments where containers are stacked on each other, and in the transport of heavy or odd-shaped products.

Although per capita use of lumber for containers has been declining materially, an expanding economy should require a large volume of lumber for this use. So despite substitution of other materials for lumber, the container market is expected to continue to provide an outlet for considerable quantities of low-grade white pine.

A preferred species for many manufactured products.--For manufactured products the competitive position of white pine is quite different. Here white pine is a preferred species that returns a premium price.

Although the white pines represented only 5 percent of total softwood lumber production in 1948, they accounted for 10 percent of the softwood lumber used for manufactured products. For some products, notably boot and shoe findings, patterns and flasks, and matches, preference for the white pines is very great. The following tabulation (9) shows the principal manufacturing uses of white pines and the importance of white pines in such uses in 1948.

	Eastern white pine	Sugar and western white pine	All white pines	Proportion of all softwood use
	Million board feet	*Million board feet*	*Million board feet*	*Percent*
Use:				
Patterns and flasks	42	23	65	72
Millwork[1]	39	126	165	8
Furniture and fixtures	36	11	47	12
Boot and shoe findings	30	1	31	95
Toys	9	2	11	40
Map and shade rollers	7	5	12	58
Ship and boat building	5	3	8	13
Matches	0	34	34	98
Other	52	21	73	4
Total	220	226	446	10

[1] Includes flooring.

There also is evidence that preference for white pine lumber for such uses is increasing. During the 15-year period 1933-48 use of eastern white pine lumber for manufactured products quadrupled while use of all softwoods tripled (14; fig. 19).

Market Outlook Good for Quality White Pine

The above facts indicate that much of the past decline in eastern white pine lumber consumption was due to short supply. Since eastern white pine now represents only about 5 percent of all softwood lumber used in manufactured products, for which it is strongly preferred, a much greater volume can undoubtedly be sold for these products as increased supplies of suitable pine become available, and as western old-growth timber resources decline.

In a sense, the low-grade white pine lumber sawn at the mills is a byproduct of high-quality pine lumber. The construction and container markets should continue to provide an outlet for these lower grades of white pine lumber. With the expected great expansion in the Nation's population and economy, the volume of lumber used for construction and containers should increase considerably. Recent Forest Service projections indicate potential demands by the year 2000 for 30 to 115 percent more construction lumber than is used today, and a potential increase of from 27 to 112 percent

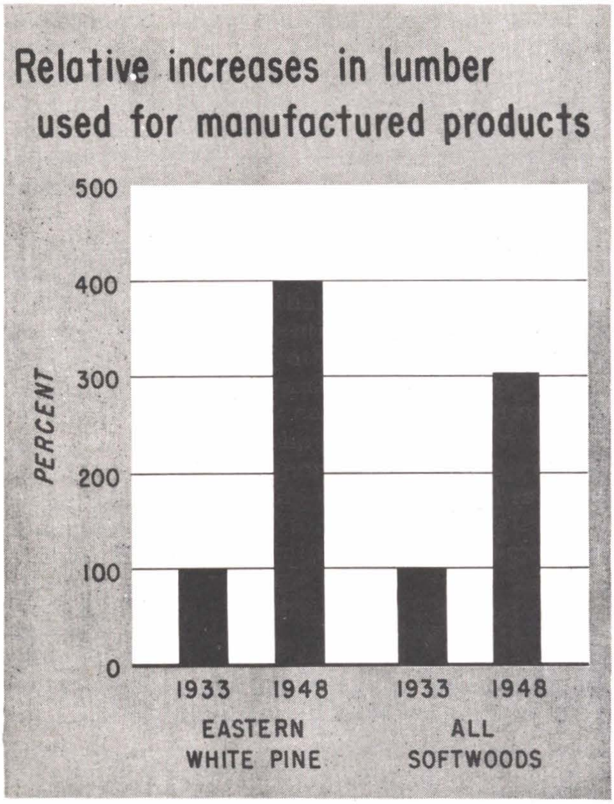

Figure 19

in demand for container lumber (17). However, these lumber markets will be dominated by western and southern species produced in much greater volume than eastern white pine. Possibly the competitive position of eastern white pine in eastern markets will improve somewhat as population and local demand for lumber in the West build up, and as the quality and volume of old-growth western timber is reduced. At the present rate of cutting, it is likely that most of the remaining old-growth western timber will be utilized within the next 40 to 60 years. Nevertheless, markets for low-grade lumber will be highly competitive as they are today, with prices based on major competing species more plentiful than eastern white pine.

The market outlook for high-quality eastern white pine is much more promising. Forest Service projections indicate a potential lumber demand for manufacturing use by the year 2000 of twice the volume consumed for this use in 1952. Even now the total market for lumber of grades suitable for manufacturing use is 20 times the volume of eastern white pine so used. If the preference for eastern white pine in manufacturing use is maintained merely at present levels, prospects for increased use are bright. Factors already discussed indicate that the proportion of all softwoods used in manufacturing represented by eastern white pine will increase if additional supplies of this species become available.

Further indication of strong demands for high-quality eastern white pine lumber in contrast to low-quality lumber is shown by comparisons of prices among lumber grades. Figure 20 shows the very large differences in price between Select and Common lumber grades.[6] In 1957, the average price of D and Better Select grade lumber was 184 percent greater than the price of #4 Common, 84 percent greater than #3 Common, and 34 percent greater than the price of #1 and #2 Common lumber.

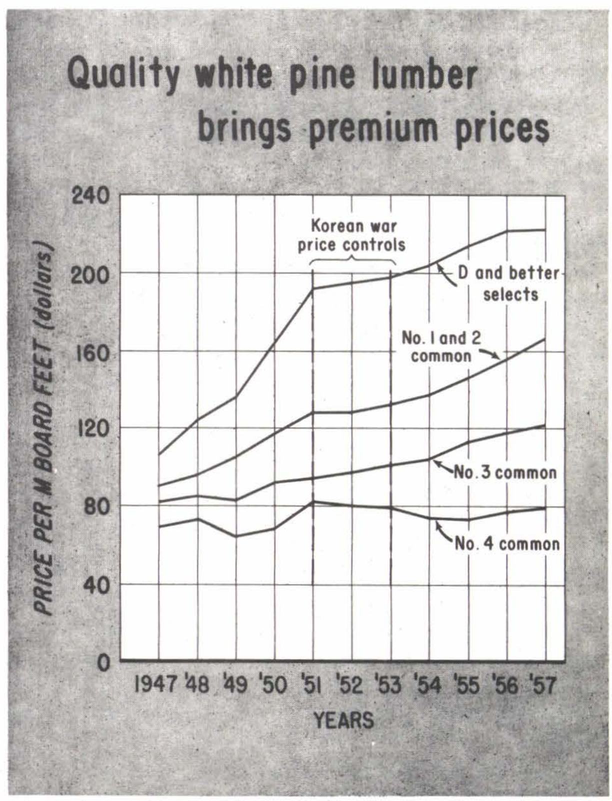

Figure 20

These premium prices justify special protection and management treatments

[6] F.o.b. mill prices based on midpoints of price range for each grade as quoted in the Boston Commercial Bulletin; average for sizes 1 x 4, 1 x 5, and 1 x 6, 7, and 8.

required to produce quality white pine in many Lake States stands. Which stands, and the amount of such work that can be economically justified, depend in part on the value of additional pine produced at time of harvest. Accordingly, the outlook for future lumber and stumpage prices is of great importance.

Projections Indicate Rising Lumber and Stumpage Values

Recent studies (13, 17) indicate increased potential demands for lumber in relation to available supplies. These estimates imply rising values for stumpage and for lumber by the time young eastern white pine stands reach maturity. Past price trends and relationships were considered to give some indication of prospective increases. The price trend of lumber between 1915 and 1956 was compared with that of other commodities (5). In this period the relative lumber price increased from 37 to 112 (1947-49 = 100). Because of change in grade mix, the actual increase was even greater. If the Bureau of Labor Statistics lumber price index continues to rise on the same trend as in the period 1915-56, prices will increase a further 50 percent during the next 30 years.

The current analysis is based upon the assumption that the price of lumber will continue to increase annually by an average of 0.5 percent of the 1958 price level. This would mean a 25-percent increase during the next 50 years. The analysis is also based on the assumption that there will be an increase in the cost of converting trees into lumber. The differential between the increased lumber price and the increased conversion costs is assumed to be such that average stumpage values will increase annually by an average of 1 percent of the 1958 price level. This stumpage price applies to trees of the same size and quality harvested from second-growth stands in 1958 in the leading white pine producing region.

The most active markets for second-growth eastern white pine stumpage today are in the New England States, where white pine stumpage values average about $20 per thousand board feet. Very little second-growth white pine is now sold in the Lake States, but it is likely that when the young stands in the region mature, Lake States white pine generally will be sold in the same type of markets at about the same prices as New England pine. Therefore, estimated future values of Lake States white pine stumpage are based on an average of $20 per thousand board feet in 1958 plus 1.0 percent of this amount, or 20 cents, per year. Stumpage value 50 years hence, for example, for white pine of the average quality and size harvested in 1958 is estimated at $30 per thousand board feet. From this base value for trees of current average size and quality, adjustments in value are made, by procedures described below, to reflect changes in tree quality or size anticipated as a result of specified management treatments under various stand conditions.

Prospective Stumpage Value Depends Greatly on Quality and Size of Logs

The white pine timber now being harvested in New England has an average Quality Index of 67 (page 18). The difference in stumpage values of stands with different QI's was calculated by the formula:

$$\text{Difference} = \left(\frac{\text{QI-67}}{100}\right)\left(\begin{array}{l}\text{average price of \#1}\\ \text{and \#2 Common lum-}\\ \text{ber at time of harvest}\end{array}\right)$$

The average price of #1 and #2 Common lumber in 1958 was about $170 per thousand board feet. This is assumed to increase an average of 0.5 percent of present value, or 85 cents per thousand board feet per year in the future. Thus for trees of the size cut in 1958, the potential value of white pine stumpage of any specified quality (average QI) and future harvest date is estimated as follows:

$$\text{Value per M board feet} = \$20 + \$0.20(\text{harvest date} - 1958) \text{ plus } \left(\frac{\text{QI-67}}{100}\right)[\$170 + \$0.85\,(\text{harvest date} - 1958)]$$

This value must be further adjusted to reflect additional value of stumpage associated with the increase in size of trees expected in future second-growth stands. Logging and milling costs per thousand board feet are less for large trees than for small trees. For example, an eastern white pine stand averaging 20 inches d.b.h. costs 35 percent less to convert to lumber than a stand averaging 12 inches d.b.h., according to unpublished results of studies conducted at typical Northeastern sawmills. Corresponding conversion cost differentials for

eastern white pine stands averaging different diameters are as follows:

Average stand d.b.h. at harvest (inches)	*Percent of 12-inch d.b.h. conversion cost saved*
10	-15
11	-7
12	0
13	6
14	11
15	16
16	20
17	24
18	28
19	32
20	35
21	38
22	40
23	41
24	42
25	42

Further adjustment is made to reflect the trend in variable conversion costs. Total conversion costs, including all logging and milling costs plus an overhead and profit margin, now average about $90 per thousand board feet for eastern white pine lumber. Total conversion cost can be divided into fixed costs and variable costs which change with time and conditions. Variable conversion costs now average about $26 of the $90 total cost per thousand board feet, and are expected to increase 10 cents per thousand board feet per year in the future. The additional stumpage value of future stands with pines averaging larger than 12 inches d.b.h., the average size now being harvested, thus can be determined by multiplying the percentage differential in conversion costs of stands averaging more than 12 inches d.b.h. by the projected variable conversion cost for 12-inch d.b.h. stands at time of harvest.

Summarizing, the stumpage value of any stand at any future date can be computed as follows:

$$\text{Value per M board feet} = \$20 + \$0.20(\text{harvest date} - 1958) + \left(\frac{QI-67}{100}\right)[\$170 + \$0.85(\text{harvest date} - 1958)] + (\text{conversion cost differential})\,[\$26 + \$0.10\,(\text{harvest date} - 1958)]$$

APPRAISING RUST CONTROL PROFITABILITY IN INDIVIDUAL WHITE PINE STANDS

We have described the major factors that influence the cost of controlling blister rust. We have also discussed those factors that affect the value of pine which can be saved by rust control. The next step is to combine these factors into a procedure that can be used to assign control priorities to different stands on the basis of profitability.

Working Tools Developed To Aid Evaluation

Three working tools were developed to simplify application of procedures for evaluating the profitability of blister rust control in individual stands.

The first is a field plot tally form (EWP-1) for recording data regarding stand condition variables on sample plots throughout the stand (fig. 21). The second is a combined stand condition summary form (EWP-2) and computation work sheet. The front side of this form (fig. 22) provides a summary of sample plot data and other variables determined in the field for the stand as a whole. The back side (fig. 23) is a computation work sheet which outlines calculations required to evaluate rust control profitability in the stand.

The third working tool, "Lake States Blister Rust Control Evaluation Calculation Aid," includes a set of matched data cards inserted in a coded cover (fig. 24). The fitted insert cards are for each site index class. The Calculation Aid, which is used somewhat like a slide rule, directly provides results of completed calculations pertaining to potential pine yield, quality and value, losses caused by blister rust and weevil, rust control costs, stand treatment, and other related factors needed to complete calculations of rust control profitability in the stand being appraised.

Appraisal Involves Seven Separate Steps

The cost, volume, and value factors brought together in the Calculation Aid were discussed in preceding sections of this report. Detailed instructions for practical field application of the evaluation procedure are presented in the attached field manual (Appendix B). This section briefly explains the procedures used to combine the many interrelated individual factors in appraising

Form EWP-1

BLISTER RUST CONTROL EVALUATION FORM

Plot Tally Sheet

Area No. ______ Percent of plot occupied by white pine _____ Plot No. _____ of ___

Pine Stocking and Weevil Injuries on 1/10-Acre Sample Plot

Crop tree no.	DBH 1/	No. of weevil injuries	Crop tree no.	DBH	No. of weevil injuries	Crop tree no.	DBH	No. of weevil injuries
1			23			45		
2			24			46		
3			25			47		
4			26			48		
5			27			49		
6			28			50		
7			29			51		
8			30			52		
9			31			53		
10			32			54		
11			33			55		
12			34			56		
13			35			57		
14			36			58		
15			37			59		
16			38			60		
17			39			61		
18			40			62		
19			41			63		
20			42			64		
21			43			65		
22			44			Totals		

1/ To nearest 0.1 inch. Record all seedlings less than 1.0 inch d.b.h. as 0.5 inch

Figure 21

Form EWP-2, front side

BLISTER RUST CONTROL EVALUATION FORM

Stand Summary and Computation Sheet

District ____________ County ____________ Area no. _________ No. of plots _____ Date __________ Estimator __________

SITE INDEX

MATURE DOMINANTS

Tree no.	Age	Total height	Site index
Average site index for stand: ________			

JUVENILE DOMINANTS

Tree no.	Age	Total height	DBH 1/10 ht.	Site index
Average site index for stand: ____________				

STAND VARIABLES

No. of future workings needed to establish rust control: 1 2 3 4
Man-days per acre of pine area to complete all future workings: ______
Average d.b.h. of crop trees: (Sum of diameters) (No. pine crop trees) ________ ÷ ________ = ________
Average no. pine crop trees per plot: (No. pine crop trees) (No. of sample plots) ________ ÷ ________ = ________
Gross harvest volume per acre: (Gross yield) (No. of plots) ________ ÷ ________ = ________
Weevil injuries per ft. of pine bole: (Tot.no. injuries) (Av.tree height) (No. pine crop trees) _____ ÷ (_____ × _____) = _____

SUMMARY OF PINE STOCKING ON SAMPLE PLOTS

Plot no.	No. pine crop trees	Sum of diameters	No. weevil injuries	Percent of area occupied	Yield if fully occupied 1/	Gross yield
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
Stand totals				xx	xx	

1/ Item G from Calculation Aid

Figure 22

Form EWP-2, back side

RECORD PRIMARY VARIABLES HERE

1. BR hazard zone	High	Medium		Low
2. Weevil control		No		Yes
3. Release		No		Yes
4. Thinning		No		Yes
5. Pruning		No		Yes
6. Rotation age	80	100		120
7. Site index	40 50	60	70	80
8. Av. no. of crop trees per plot				____
9. Av. DBH of crop trees				____
10. Av. weevil injuries/foot				____
11. No. of future workings	1	2	3	4
12. Total no. of man-days per acre				____
13. Gross harvest volume per acre				____

MAKE THE FOLLOWING CALCULATIONS--Sources of data are indicated by numbers or letters in parentheses above each blank. Numbers refer to items on this sheet; letters to items on the Calculation Aid.

14. Normal age: (A) ____

15. Length of control period: (6) ____ - (14) ____ - 6((11) ____ - 1) = ____

16. Length of investment period: (6) ____ - (14) ____ = ____

17. Harvest date: (Present year) ____ + (16) ____ = ____

18. Harvest volume saved (M board feet per acre): (B) ____ [(13) ____ - ((2 no-H) (2 yes-I) ____ x (10) ____)] =

19. Adjustment in quality index: .04 + ((4 no-.00) (4 yes-.05)) ____ + ((5 no-.00) (5 yes-J)) ____ - (.35 x (10) ____ x ((2 no-1.00) (2 yes-K)) ____) = ____

20. Unit harvest value (dollars per M board feet): (C) ____ + ((19) ____ x (D) ____) + ((L) ____ x (E) ____) = $____

21. Thinning value saved (dollars): ((M) ____ x (B) ____) [(20) ____ - (((5 no-.00) (5 yes-J)) ____ x (D) ____)] = $____

22. Rust control cost (dollars per acre): (12) ____ x (F) ____ = $____

23. Profit or loss per acre (dollars): ((18) ____ x (20) ____) + (21) ____ - (22) ____ = $____ per acre

24. Value returned per dollar spent (dollars): [((18) ____ x (20) ____) + (21) ____] ÷ (22) ____ = $____ per dollar

Figure 23

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

Division of Forest Economics Research
in cooperation with
Division of Forest Pest Control

LAKE STATES BLISTER RUST CONTROL EVALUATION
CALCULATION AID

MODEL I
1959

SITE INDEX 70

AVERAGE DBH OF CROP TREES 5.6-6.5
31 A

CROP TREES PER 0.1 ACRE 26-29
THINNING YES

PROPORTION OF STAND SAVED BY RUST CONTROL

LENGTH OF CONTROL PERIOD		0-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
HAZARD ZONE	HIGH	.00	.12	.22	.31	.39	.46	.53	.58	.62	.67	.71	B
	MEDIUM	.00	.05	.11	.15	.20	.24	.28	.32	.36	.39	.42	
	LOW	.00	.01	.02	.03	.04	.06	.07	.08	.09	.10	.11	

STUMPAGE VALUE AT TIME OF HARVEST

HARVEST DATE	1981-1990	1991-2000	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2051-2060	2061-2070	2071-2080	2081-2090	2091-2100	
	25	27	29	31	33	35	37	39	41	43	45	47	C
	193	202	210	218	227	235	244	252	260	269	277	285	D
	29	30	31	32	33	34	35	36	37	38	39	40	E

COST PER MAN-DAY OF RUST CONTROL

LENGTH OF INVESTMENT PERIOD		31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
NUMBER OF FUTURE WORKINGS	ONE	83	106	136	174	223	285	365	467	599	F
	TWO	79	101	130	166	213	272	349	446	571	
	THREE	77	98	126	161	206	264	338	432	553	
	FOUR	75	96	123	158	202	258	331	423	542	

STAND VOLUME AND VALUE FACTORS

32.4	G	ROTATION AGE 80
63.1	H	
44.4	I	
.22	J	
.76	K	
.15	L	
3.5	M	
40.6	G	ROTATION AGE 100
68.5	H	
50.2	I	
.25	J	
.81	K	
.25	L	
9.3	M	
45.8	G	ROTATION AGE 120
69.5	H	
51.7	I	
.24	J	
.83	K	
.32	L	
16.5	M	

Figure 24

rust control profitability in any stand. These are described below as seven separate steps, the headings of which correspond with items 18-24 on the computation work sheet (fig. 23).

Item 18. Harvest volume saved.--The potential volume of pine at time of harvest that could be saved by rust control is estimated in terms of M board feet per acre. This is computed as follows:

Volume saved = [(gross harvest volume) - (volume loss to weevil)] x (percent of stand that could be saved by rust control)

Gross harvest volume is the potential gross volume per acre of the stand at rotation age assuming insignificant losses to rust and weevil. Estimates of yield per acre at harvest for areas fully occupied by pine are based on Lake States yield tables and are obtained from table 11 as explained on page 15, or item G on the Calculation Aid. Gross harvest volume in M board feet per acre is computed for each plot by multiplying the estimated yield at harvest if area is fully occupied, by the percent of area occupied by pine. This discounting is done to prevent overestimating yields. For example, if half of a plot supports no white pine, normal yield cannot be expected from that plot no matter what conditions exist on the other half occupied by pine. This procedure attempts to recognize only relatively large openings in the pine stand. Therefore, only 1/100-acre or larger openings were recognized in judging occupancy by pine. The crop tree tally reflects the occurrence of small holes in the occupied portion of the plot.

Volume loss to weevil is the potential volume per acre that is expected to be lost by weevil damage with or without weevil control. These figures are obtained by use of the formula presented on page 15. The weevil loss calculated by this formula for each stand condition was divided by the number of weevil injuries per foot of pine bole to obtain factors H and I on the Calculation Aid. Potential weevil loss in M board feet per acre is computed by multiplying the number of injuries per foot of stem in the stand sampled by factor H if no control is anticipated, or by factor I if weevil control is planned.

Percent of stand that could be saved by rust control depends on the hazard zone in which the stand is located and the number of years between establishment of control and harvest. These figures are obtained from figure 11, and are shown in item B on the Calculation Aid.

Item 19. Adjustment in quality index.--The average quality index of unmanaged white pine currently being harvested is 67, including a loss of 4 index points due to weevil damage (page 18). Since the value of pine saved by rust control depends in part on the quality of pine at harvest, the average quality index of unmanaged stands must be adjusted to reflect the effects of anticipated management treatments on pine quality. This adjustment of the current average index 67 is computed as follows:

Adjustment in QI = (increase to remove effects of average rate of weevil damage) + (increase for thinning) + (increase for pruning) - (decrease for local rate of weevil damage)

Increase to remove effects of average rate of weevil damage. An increase of 4 index points is added to the current average quality index of 67 to remove the average effects of weevil damage on the quality of pine now being harvested. This makes possible a later adjustment for weevil damage reflecting local rates of injury in the stand being appraised.

Increase for thinning. In thinned stands the quality index of the final harvest is increased 5 index points to reflect improvement due to thinning (see page 19). If no thinning is anticipated, no adjustment is made.

Increase for pruning. The increase in quality index due to pruning varies with site and stand conditions as explained on page 19. The figure for each stand condition is obtained from table 14, and is item J on the Calculation Aid. Where no pruning is anticipated, no adjustment is made.

Decrease for local rate of weevil damage. The loss in quality index reflecting local rates of weevil injury is calculated by the formula below (see page 18):

QI loss = 35.2 (number of injuries per foot of bole) (percent of tree volume unprotected)

With weevil control anticipated, the percent of tree volume unprotected is item K on the Calculation Aid. Without control, of course 100 percent is unprotected.

Item 20. Unit harvest value.--The anticipated value per M board feet of white pine

stumpage at time of harvest is computed as follows:

Stumpage value per M = (base value of pine stumpage) + (effect of improved quality) + (effect of larger tree size)

Sources of data and procedures used to determine stumpage value were previously defined (page 24).

Base value of pine stumpage. The value of pine stumpage of the quality and size now being harvested is item C on the Calculation Aid, and is computed as follows:

Value per M = \$20 + \$0.20 (harvest date - 1958)

Effect of improved quality. The increase in stumpage value reflecting the higher quality of pine anticipated due to protection and management is computed as follows:

Increase in value = (adjustment in quality index) (average price of #1 and #2 Common lumber at time of harvest)

The figure for adjustment in quality index is obtained from item 19 in the preceding section. Average price of #1 and #2 Common lumber is now \$170 per M board feet and is expected to increase \$0.85 each year hereafter (page 24). This figure, at any future date, is item D on the Calculation Aid.

Effect of larger tree size. The increase in stumpage value reflecting lower conversion costs due to larger trees at harvest is computed as follows:

Increase in value = (conversion cost differential) (projected variable conversion cost for 12-inch trees)

The conversion cost differential is the percent of conversion costs for 12-inch d.b.h. trees saved by harvesting larger trees. The figure is obtained from the tabulation on page 25, and is item L on the Calculation Aid. The projected variable conversion cost for 12-inch trees is item E on the Calculation Aid, and is computed as follows:

Projected variable conversion costs = \$26 + \$0.10 (harvest date - 1958)

Item 21. Thinning value saved.--The value of thinnings that can be saved by blister rust control must be added to the value of additional pine in the final harvest saved to determine the total potential benefits that can be gained by rust control. The value at time of final harvest of thinnings saved by blister rust control is determined as follows:

Thinning value saved = (thinning factor) (percent of stand that could be saved by rust control) [(unit harvest value) - (value due to pruning)]

The thinning factor represents the volume removed in thinnings, under each specified stand condition, expressed in terms of harvest volume, and takes into account differences among multiple thinnings in quality, price level, and time of successive thinnings.

In deriving the value of thinnings, it was assumed that an equal volume is removed in each thinning, that thinnings occur at 10-year intervals with none before age 50, and that total thinning volume is reduced 10 percent by weevil damage.

With more than one thinning, the unit value of pine cut in each successive thinning is greater than that of the preceding thinning because each successive thinning removes material more closely resembling the quality and size of the final harvest, and at price levels nearer that of final harvest. The difference in unit value between any two thinnings 10 years apart, expressed as a percent of the unit value of harvest cut, is equal to: 100/(total number of thinnings + 1). Thus, in stands where three thinnings are planned, the first will have a unit value of 25 percent of the unit harvest value, the second 50 percent, and the third 75 percent. The values at time of thinning are then projected to time of harvest using the risk-free compound interest rate of 2.5 percent as in all interest computations in this analysis. Accordingly, the total value at time of harvest of three thinnings would be:

.25 (unit harvest value) (.9) (total thinning volume ÷ 3) ($1.0p^{30}$)
+.50 (unit harvest value) (.9) (total thinning volume ÷ 3) ($1.0p^{20}$)
+.75 (unit harvest value) (.9) (total thinning volume ÷ 3) ($1.0p^{10}$)

One additional step was taken to simplify field use of this procedure. For each stand condition, the total value of thinnings (computed as above) was divided by the corresponding unit harvest value to obtain

the thinning factor, item M on the Calculation Aid. These thinning factors are presented in table 16.

Percent of stand that could be saved by rust control is item B on the Calculation Aid. Derivation of this figure was previously explained on page 9.

Unit harvest value is the anticipated value per thousand board feet of pine at time of final harvest. Derivation of this figure was previously described as item 20.

Value due to pruning is subtracted from the unit harvest value in computing the value of thinnings saved because pruned trees generally will not be cut in thinnings. This figure is zero in unpruned stands. For stands where pruning is planned, this figure is computed as follows:

Value due to pruning = (increase in QI due to pruning) (average price of #1 and #2 Common lumber)

The increase in QI due to pruning is item J, and the average price of #1 and #2 Common lumber is item D on the Calculation Aid, the derivations of which were previously explained on pages 19 and 30.

Item 22. Rust control cost.--The cost of establishing rust control on areas requiring future treatment is calculated as follows:

Control cost = (number of man days) (cost per man-day)

Number of man-days of field labor required to complete all future workings needed to establish rust control is estimated in the field (page B-3, Appendix B).

Cost per man-day is defined on page 12. The cost per man-day figure is obtained from the tabulation on page 12, and is item F on the Calculation Aid.

Item 23. Profit or loss per acre.--The profitability of future work to establish blister rust control in any stand is calculated as follows:

Profit or loss per acre = (harvest volume saved) (unit harvest value) + (thinning value saved) - (rust control cost)

Each of the above figures required to calculate potential profit or loss per acre is obtained from computations explained in preceding sections as items 18, 20, 21, and 22 respectively.

Item 24. Value returned per dollar spent.--The potential value of additional pine that could be saved per dollar spent for rust control is determined as follows:

Return per dollar = [(harvest volume saved) (unit harvest value) + (thinning value saved)] ÷ (rust control cost)

The figures needed to compute value returned per dollar spent for rust control are the same as those used in determining profit or loss per acre.

This potential value of return per dollar spent for rust control, including interest and margin for risk, is a major goal of this analysis. If the return per dollar of costs is more than one dollar, the stand can be profitably worked. The ratio of returns to costs provides a means of comparing profitability of future rust control work in individual stands and an economic basis for selecting the most profitable white pine areas in which to concentrate future rust control effort.

GUIDES FOR AN ECONOMIC RUST CONTROL PROGRAM IN THE LAKE STATES

The final step in the analysis is consideration of various regional aspects of applying the economic procedure for selecting stands to receive rust control treatment that can help guide future policy formulation and rust control program planning. To determine the extent and distribution of Lake States white pine areas by different levels of return on rust control investments, the evaluation procedure outlined in previous chapters was applied to field data gathered on random plots throughout the region in the 1957 site-stocking survey.

Regional Estimates Have Limitations, But, Provide Helpful Guides

Some of the data presented in this chapter have limitations due to the sampling system used to determine the characteristics of the white pine resource. The site-stocking survey was designed to obtain a general picture of site, stocking, and other conditions on all lands throughout the region that bear white pine. Time and manpower limitations made it necessary to use well-distributed single random plots, rather than groups of plots which would better

measure average conditions in individual stands.

The survey provided valid estimates of regional resource totals, average conditions, and distribution of area by condition classes based on 1/10-acre plots. It did not provide estimates of average conditions in individual stands nor of variability within stands. Sampling based on groups of plots in individual stands would have indicated somewhat less area in the extremes of range than that shown below.

The estimates in the following section, because of the circumstances described above, could contain considerable error and should be used with care. The broader appraisal of the regional situation presented, however, indicates major conditions and resource potentials that should be helpful in guiding forest administrators and policy-makers responsible for planning white pine management programs in at least three ways by providing: (1) A general estimate of the potential white pine volumes and values in existing Lake States white pine stands, and of the effects that alternative management treatments would have on potential returns from these stands; (2) a basis for evaluating the amount of future rust control work that would be economically justifiable in the Lake States; and (3) a basis for allotting rust control funds, under any level of program activity, to areas that will return the greatest returns on such investments.

Less Than Half of Pine Area Needs Future Rust Control Treatment

Although the Lake States contain $1\frac{1}{4}$ million acres of white pine, less than a half-million acres need future treatment to establish blister rust control (fig. 25). With the relatively short cutting rotations assumed in this study, pine stands 50 years or more in age are normally considered too old for profitable rust control treatment. The $1\frac{1}{4}$ million acres include about 355,000 acres of these older stands, which are most prevalent in northern Minnesota and Wisconsin (table 17). Subtracting the area of older stands leaves 891,000 acres in stands less than 50 years of age. Included are 45,000 acres of stands in which all pines are suppressed and unlikely to develop unless released. Of this, about 15,000 acres need additional rust control treatment which, however, should not be undertaken unless the pines are released.

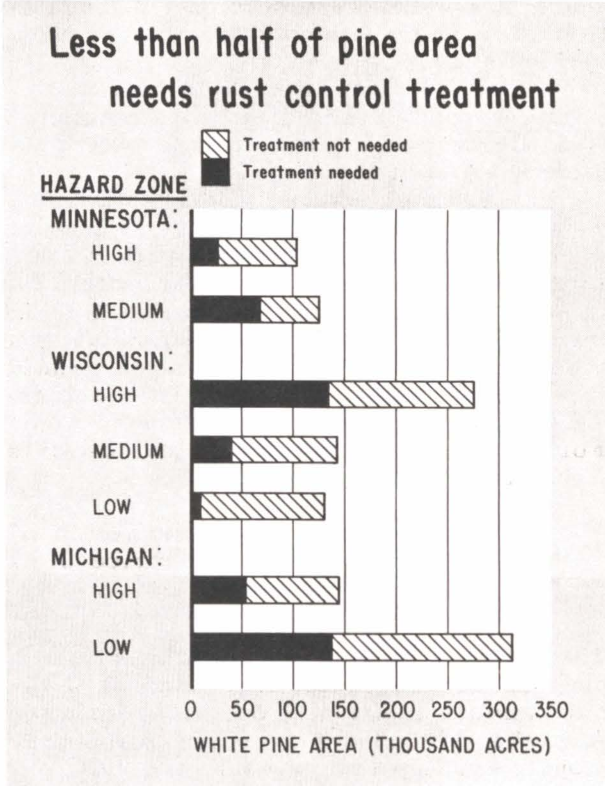

Figure 25

An additional 367,000 acres with stands less than 50 years old were judged by the rust control technicians who made the survey as not needing future treatment. Here control has already been established or, because of favorable microclimatic or ribes conditions, no treatment is required. Only the remaining 479,000 acres were judged in need of future treatment to establish rust control at a level that could be maintained thereafter by occasional maintenance work.

What Are the Potential Pine Volumes And Values at Stake?

Existing stands could produce 25 billion board feet.--The gross volume of white pine at maturity that could be produced from existing stands in the Lake States is 25 billion board feet--more than seven times the present pine sawtimber volume. This volume could be produced if all management treatments considered in this analysis were applied where needed in stands now less than 50 years old. With no treatments applied, the potential yield of existing stands at maturity is 19 billion

board feet. Potential yields with alternative combinations of treatments lie between these extremes as shown in figure 26. The stand age at maturity used in this analysis varies from 80 to 120 years depending on site productivity and ownership class as follows:

Ownership class	*Age by site index--*				
	40	*50*	*60*	*70*	*80*
Federal, State, or county.......	120	120	100	100	100
Private..........	100	100	80	80	80

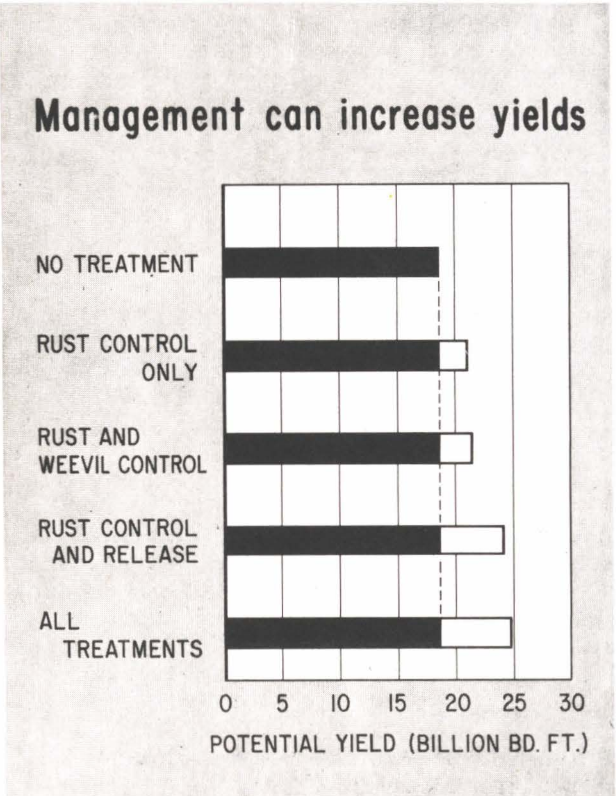

Figure 26

As presented here, all comparisons of potential pine volumes and values with alternative management treatments are estimates of yields at maturity with the specified treatments applied only in stands where needed. These regional estimates reflect the effects of treatments where applicable under stand conditions existing today. They do not indicate the magnitude of benefits that could be gained by application of treatments throughout the life of individual stands. Differences in volume and value of potential yields with alternative treatments would be considerably greater than the regional estimates shown in this section if the treatments were applied everywhere at proper stand ages.

Almost three-fourths of the potential yield of 25 billion board feet is attributed to young stands now less than 50 years old. The potential yield of white pine from these young stands at maturity varies from 11 to 17 billion board feet, depending on which management treatments are applied (table 18). The older stands now 50 years of age or more, if allowed to grow to maturity, have a potential yield of 6.1 billion board feet. The potential yield at maturity of scattered white pine sawtimber trees now overtopping young stands is about 1.5 billion board feet. Thus the potential white pine yield of existing Lake States stands ranges from about 19 to 25 billion board feet, depending on the treatment given stands now less than 50 years old.

Corresponding estimates of the potential gross value at maturity of white pine in existing Lake States stands range from $709 million with no treatment to $1.9 billion with all treatments applied where needed (table 19).

Three billion board feet of pine could be saved by future rust control work.--The potential white pine yield of young stands on the 479,000 acres in need of additional rust control treatment could be increased about 3 billion board feet by future control work. The potential pine volume that could be saved from blister rust on the 479,000 acres varies from 2.5 to 3.0 billion board feet depending on what other management measures also are applied (tables 20 and 21). The corresponding potential volumes saved on the 320,000 acres that could be profitably treated range from 2.2 to 2.9 billion board feet (table 21).

The greatest opportunities to grow additional pine in stands under age 50 by controlling future rust losses are in the northern high rust-hazard zone. Seventy percent of this additional pine volume could be saved in the high rust-hazard zone, where losses are greatest, compared with 22 percent in the medium and 8 percent in the low hazard zones (fig. 27). In fact, half the potential volume of pine that could be saved in all existing Lake States stands by future rust control work is in the high-hazard zone of northern Wisconsin (fig. 28).

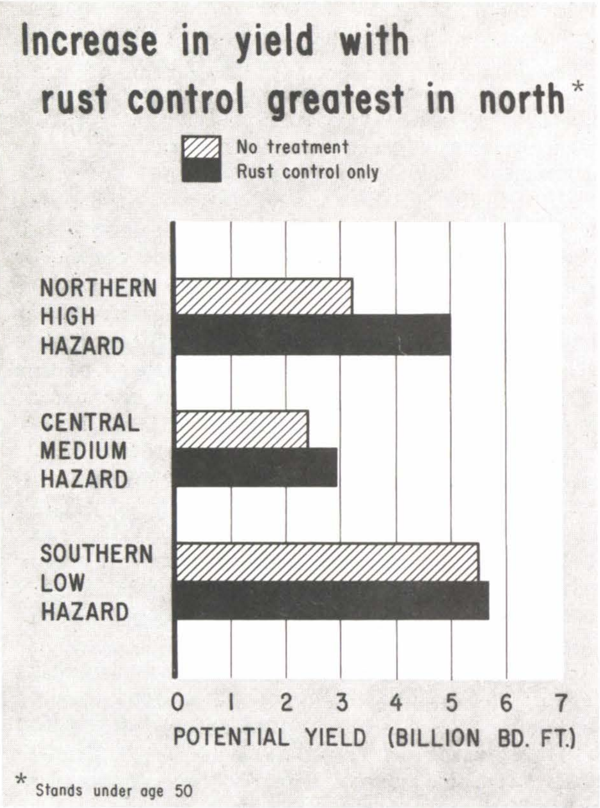

Figure 27

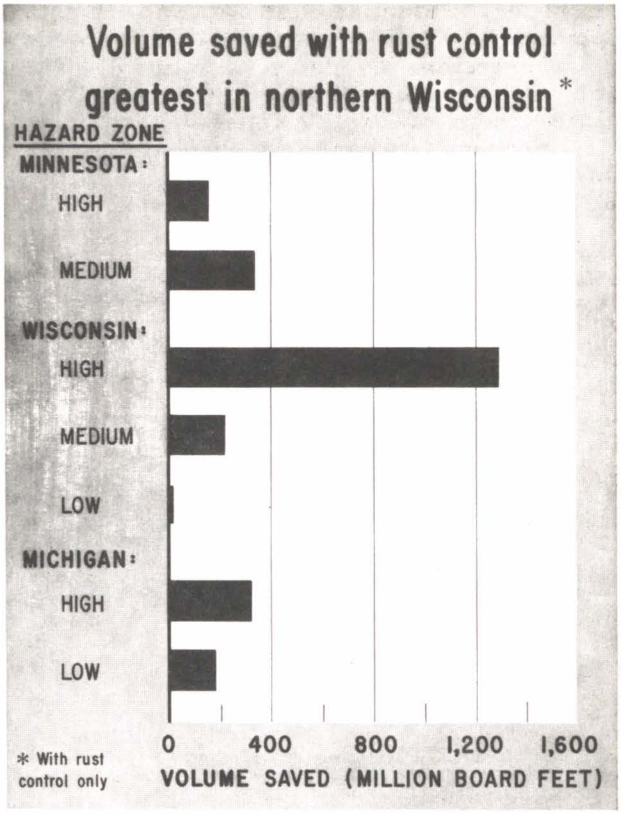

Figure 28

Rust Control Profitable On 320,000 Acres

Additional rust control work (even without other management measures) is economically justifiable on two-thirds of the 479,000 acres in need of additional treatment. Under the assumptions used in this analysis, the value of pine saved at time of harvest will exceed the costs (plus interest) of additional rust control work on 320,000 acres (table 23).

The proportion of pine area on which pine value saved will exceed rust control costs varies in different parts of the region. In northern Wisconsin, for example, additional work on about 90 percent of the 136,000 acres in need of future rust control treatment appears to be profitable (fig. 29), compared with 66 percent of the area in the southern peninsula of Michigan and 36 percent in northern Minnesota. The other extreme is in southern Wisconsin, where only 11,000 acres were classified in need of additional treatment, all of which appears unprofitable.

Rust control will be profitable on some additional areas if other management measures also are applied where needed, as shown in table 23. The area on which rust control would be profitable increases to 334,000 acres with addition of weevil control, to 367,000 acres with addition of release treatment, and to 438,000 acres with all treatments applied where needed.

Potential Value of Pine Saved Equals Four Times Control Costs

The potential value at time of harvest of the additional pine that could be saved by rust control ranges from \$119 million with rust control treatment only to \$298 million with all treatments applied where needed (tables 24 and 25). Corresponding values of pine saved on only the 320,000 acres where control treatment appears profitable vary from \$106 million to \$291 million, depending on treatment applied.

An estimated 113,000 man-days of field labor would be required to establish rust control on all the 320,000 acres where treatment appears profitable without other measures (table 26). At \$28 per man-day, establishing rust control on this area would require a cash outlay of \$3.2 million.

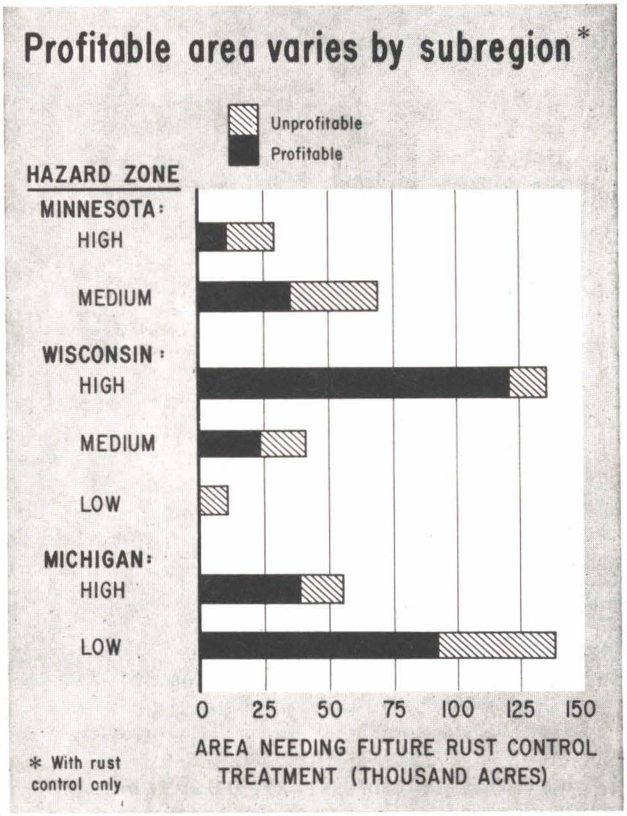

Figure 29

Including the margin for risk and $2\frac{1}{2}$ percent compound interest, the total control cost would increase to $28.5 million by the time these existing stands mature (table 26).

Thus the average ratio of returns to costs, with interest and margin for risk, is about 4 to 1 for rust control investments on all areas where benefits exceed costs. This represents an eventual return of $26 for every $1 of initial cash outlay for rust control on the 320,000 acres.

Neither the returns nor the costs described above will be incurred at any one time, but rather over a period of years. Returns will flow in over a period extending from 30 to 120 years hence. At the present level of expenditures for rust control in the Lake States, almost $400,000 per year, 8 years would be required to complete treatments now needed on all areas where additional treatment appears profitable. Although the foregoing comparisons of costs and potential returns unrealistically assume treatment in 1 year, they indicate the size of the job to be done and the level of returns that can be expected.

Potential Returns on Rust Control Investments Greatest in the North

One additional step is needed to guide the allocation of rust control funds and program emphasis among subdivisions of the region. The only measure of profitability thus far considered is 1 dollar or more of pine saved per dollar spent for rust control. The following section segregates the different parts of the white pine area according to several levels of return per dollar spent for rust control.

The ratio of returns to costs of future rust control must be considered in selecting the most profitable areas for treatment. Funds currently available for rust control activities are insufficient to treat all pine areas where additional control work is considered profitable. Available funds therefore should be allocated to areas that will return the greatest profits on such investments.

The extent and general location of the more profitable areas are defined in figure 30, which shows the distribution of pine area in need of additional treatment by ratio of potential return per dollar spent for rust control in each rust-hazard zone. Separate curves indicate the ratios of return with rust control only and with all treatments applied where needed. For all other combinations of treatments, the curves would fall between these extremes.

The northern high hazard zone contains more than ten times the area embraced in either the medium or the low hazard zone that offers a potential return of $4 or more for each $1 spent on rust control. The value of pine that could be saved by rust control exceeds four times the capitalized treatment costs on more than 100,000 acres in the high rust-hazard zone, and about 10,000 acres each in the medium and low hazard zones (fig. 30). With all treatments applied, corresponding acreages with potential returns exceeding four times control costs are 145,000 acres in the high hazard zone, 30,000 in the medium, and 93,000 in the low hazard zone.

In the most profitable stands of the medium and low hazard zones, the greatest value of pine that can be saved by rust control (with no other treatments) is about five times the capitalized treatment costs. In the high hazard zone, in contrast, returns on rust control expenditures could exceed 25 times the costs on about 10,000 acres, 20 times on 15,000 acres, 10 times

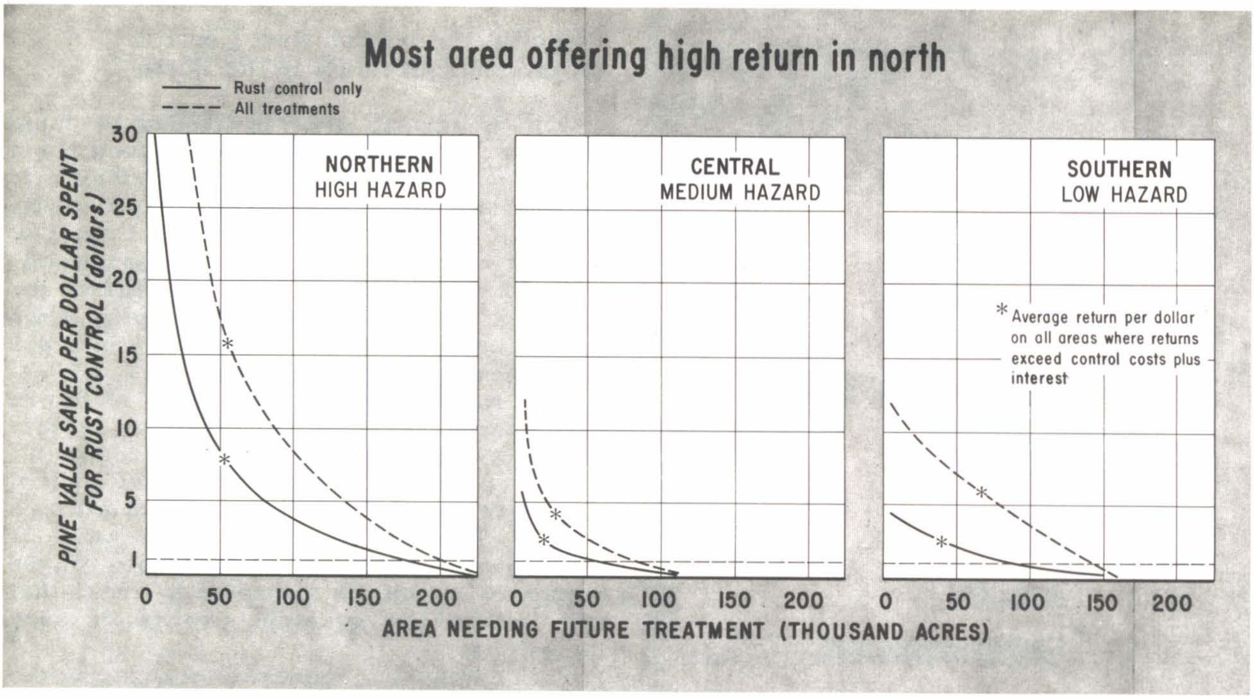

Figure 30

on 40,000 acres, and 5 times the costs on 80,000 acres of existing pine stands.

Most of the pine stands in the high hazard zone which offer large returns on rust control investments are in northern Wisconsin. As figure 31 shows, areas that can return $5 or more per $1 spent on rust control total about 4,000 acres in northern Minnesota and 21,000 acres in Upper Michigan, as against 65,000 acres in northern Wisconsin.

The ratios of potential returns to costs of rust control are much lower in all subregions of the medium and low hazard zones (fig. 32). Pine areas that can be treated profitably total 35,000 acres in central Minnesota, 24,000 in central Wisconsin, and 92,000 in Lower Michigan. But practically all of this area will return less than $5 for each $1 spent on rust control.

Thus the analysis shows that additional rust control can be economically justified on from 320,000 to 440,000 acres in the Lake States region, but to obtain the highest returns on rust control investments, the effort should be concentrated in the northern high rust-hazard zone, especially in northern Wisconsin.

Major Conclusions Same with Alternative Price Trend or Interest Rate

In the initial analysis, $20 per M board feet was used as the average stumpage value of pine now being harvested. It was assumed that stumpage value of the same size and quality pine would increase one percent of the current value each year hereafter. Treatment costs were capitalized using a risk-free, compound interest rate of 2.5 percent. To determine the effects on rust control profitability of a different price trend and interest rate, field data for stands less than 50 years old in the high rust-hazard zone of Upper Michigan were reanalyzed as follows:

The distribution of white pine area by rate of return on rust control expenditures was recalculated assuming stumpage values in the future would remain the same as at present ($20 per M board feet). Results for Upper Michigan indicated that about 60 percent of the area could be profitably treated, compared with 70 percent in the initial analysis with rising stumpage value anticipated (fig. 33).

Again these field data were reanalyzed assuming the initial rising value of stumpage,

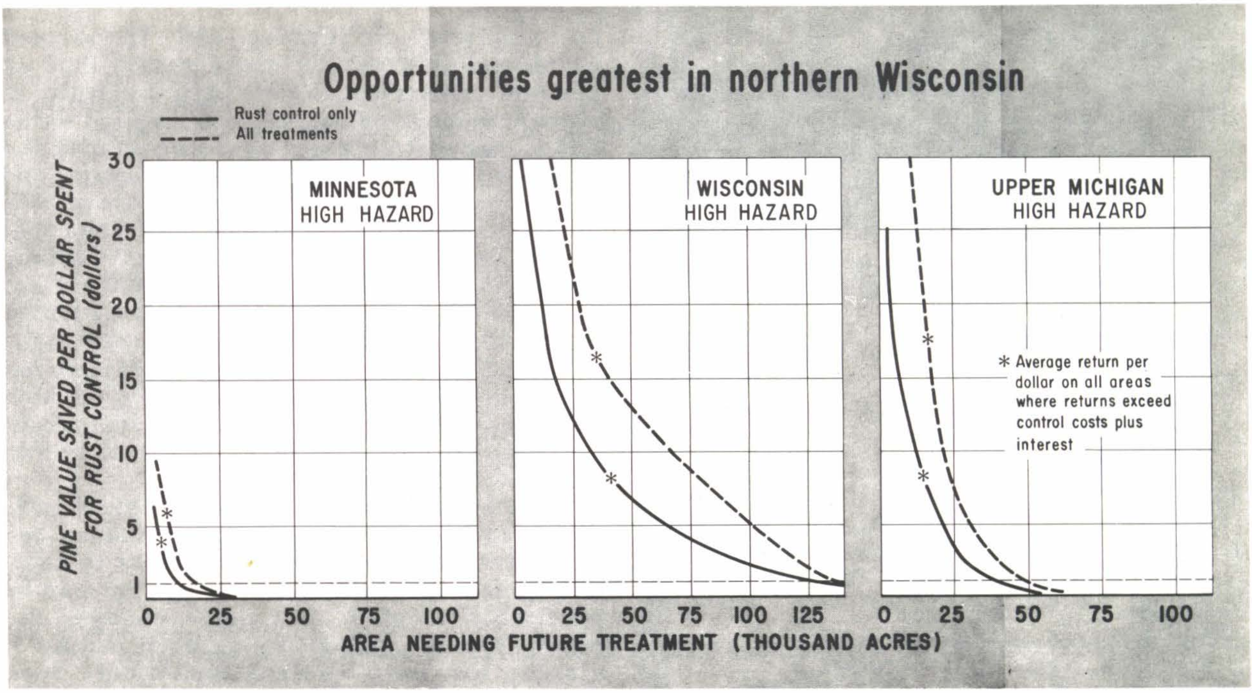

Figure 31

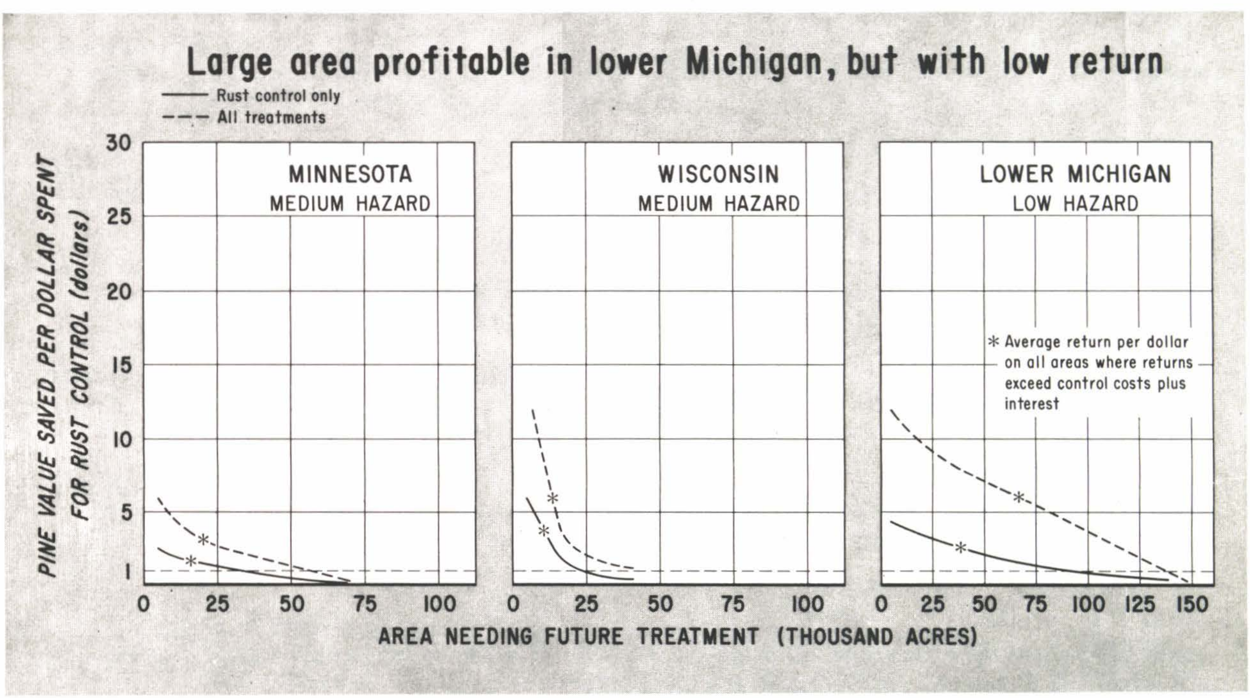

Figure 32

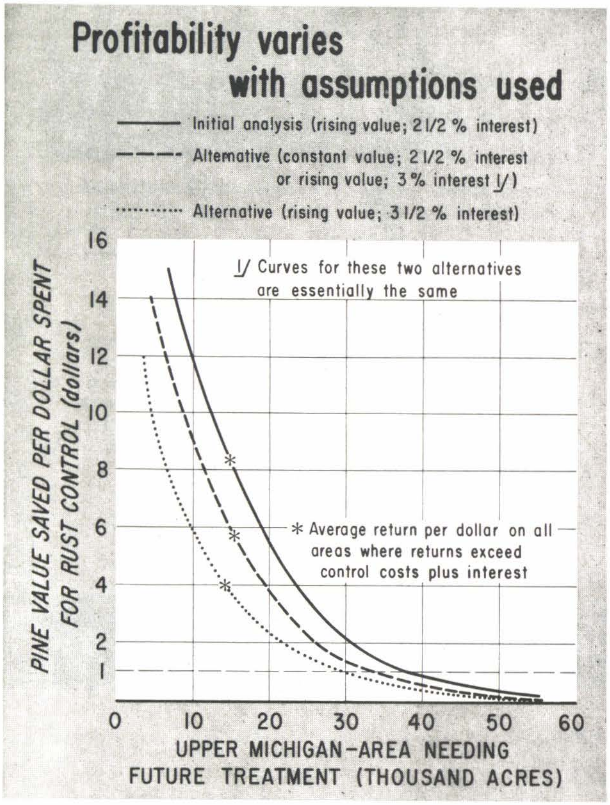

Figure 33

but applying 3 percent and $3\frac{1}{2}$ percent compound interest on costs rather than $2\frac{1}{2}$ percent. Distribution of area by ratio of return to cost using rising stumpage value and 3 percent interest was essentially the same as with constant \$20 stumpage and $2\frac{1}{2}$ percent interest. With an interest rate of $3\frac{1}{2}$ percent, the proportion of area that could be profitably treated was further reduced to about 55 percent of the total as against 60 and 70 percent in the former cases (fig. 33). Capitalized costs per man-day with 3 and $3\frac{1}{2}$ compound interest for different time intervals are shown in table 10. These may be substituted, if preferred, for item F costs (with $2\frac{1}{2}$ percent) shown on the Calculation Aid.

This selection of a higher interest rate and a lower estimate of future values reduced the ratio of expected savings to cost, and hence the estimate of area that can be profitably treated. But these changes did not materially affect the priority rating of stands for rust control treatment. Such changes therefore would not alter the major conclusions of the report, for if available funds are allocated to the most profitable areas, these funds will be exhausted long before the marginal areas are reached.

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APPENDIX A

SPECIAL FIELD SURVEYS

Rust-Incidence Survey

A rust infection incidence survey was made in the fall of 1956 (6). This involved field sampling of more than 500 randomly selected white pine plots to determine the relationship between ribes population and proportion of pines, by diameter classes, receiving fatal rust infection in specified years.

Sample plots were randomly selected from all Lake States white pine areas given ribes eradication treatment since 1952. When a pine area is treated, virtually all ribes bushes are destroyed and the number removed is recorded. Ribes populations per acre existing at time of treatment on areas surrounding sample plots were computed from these ribes eradication records. Thus for each plot, general ribes population at the time of working the area could be correlated with the rate of fatal rust infection originating during years immediately preceding eradication treatment. This was the first eradication treatment on about two-thirds of all areas examined, while the remaining third had been previously treated one or more times. The plot data collected therefore provide some comparisons of conditions on untreated areas and areas previously treated but not under control.

Each plot measured covered an area of 0.3 acre and consisted of three parallel strips one-half chain apart, five chains long, and 13.2 feet wide. More than 45,000 pines were examined on these plots. The total number of pines and the proportions fatally infected were determined for each plot by diameter class and year of infection origin. To smooth fluctuations in annual rates, the average number of pines fatally infected during a 5-year period was determined for each diameter class of pine. Rust infections must develop for several years before they become readily recognizable. Hence, to avoid error in field counts, a 4-year development period was allowed by tallying fatal infections that originated from 4 to 9 years prior to the survey apart from all earlier or later infections.

Yearly variations in incidence of new rust infections and the relationship of these variations to weather conditions were also determined. In addition to the blister rust tallies, data were collected on the frequency of white pine weevil attacks.

Site-Stocking Survey

A site-stocking survey was made in the fall of 1957. This involved field sampling of 549 randomly selected white pine plots to determine the distribution of the $1\frac{1}{4}$ million acres of white pine stands in the Lake States by major yield-cost-variable classes with reference to the profitability of blister rust control.

Pine areas sampled were randomly selected from lists of all pine areas recognized by the Branch of Forest Pest Control. The probability of selection was made proportional to acreage of white pine. Separate draws were made among areas in each rust-hazard zone in each State. To assure good distribution of sample plots, each stratum was divided into three substrata with equal acreages of white pine, and a third of all plots allotted the stratum were selected from each.

Two sizes of plots were used depending on age of pine stand: circular plots of 1/10 acre in stands averaging less than 50 years old, and circular 1/5-acre plots in older stands.

Stand variables determined on each plot included site productivity, age of stand, size and number of potential pine crop trees per acre, frequency of weevil attack, and stocking of competing species. Also, the costs of future work required to establish rust control in each stand sampled were estimated in terms of number of workings and man-days.

TABLE 1.--Area of white pine stands in Lake States blister rust control program, 1957

State	Rust-hazard zone			
	All zones	High	Medium	Low
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
Minnesota........................	233	105	127	1
Wisconsin........................	553	277	144	132
Michigan.........................	460	146	--	314
Lake States....................	1,246	528	271	447

TABLE 2.--Distribution of Lake States white pine stands less than 50 years old by percent of full pine stocking and hazard zone, with and without release, 1957

WITHOUT RELEASE

Percent of full stocking	Rust-hazard zone			
	All zones	High	Medium	Low
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
([1])............................	45	8	6	31
1-9..............................	116	53	26	37
10-29............................	380	153	81	146
30-49............................	203	84	41	78
50-69............................	119	37	23	59
70-89............................	16	6	7	3
90-100...........................	12	3	6	3
Total..........................	891	344	190	357

WITH RELEASE

Percent of full stocking	All zones	High	Medium	Low
1-9..............................	47	16	8	23
10-29............................	133	73	25	35
30-49............................	149	67	33	49
50-69............................	180	87	48	45
70-89............................	139	52	35	52
90-100...........................	243	49	41	153
Total..........................	891	344	190	357

[1] Unstocked unless suppressed pines are released.

TABLE 3.--Lake States white pine area by age of stand and hazard zone, 1957

Present age of stand (years)	Rust-hazard zone			
	All zones	High	Medium	Low
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
Less than 30....................	765	270	164	331
30-49.........................	126	74	26	26
50-69.........................	82	35	22	25
70-89.........................	140	73	30	37
90 plus.......................	133	76	29	28
Total.........................	1,246	528	271	447

TABLE 4.--Lake States white pine area by hazard zone and State and by age of stand, 1957

Hazard zone and State	Total white pine area	Stands 50 years and older	Stands less than 50 years old
	Thousand acres	*Thousand acres*	*Thousand acres*
High:			
Minnesota...........................	105	65	40
Wisconsin...........................	277	94	183
Michigan............................	146	25	121
Medium:			
Minnesota...........................	127	45	82
Wisconsin...........................	144	36	108
Low:			
Minnesota...........................	1	--	1
Wisconsin...........................	132	34	98
Michigan............................	314	56	258
Total high..........................	528	184	344
Total medium........................	271	81	190
Total low...........................	447	90	357
Lake States.........................	1,246	355	891

TABLE 5.--Lake States white pine area by site index class and hazard zone, 1957

Site index class	Rust-hazard zone			
	All zones	High	Medium	Low
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
40	124	101	11	12
50	378	199	76	103
60	504	193	116	195
70	207	32	55	120
80	33	3	13	17
Total	1,246	528	271	447

TABLE 6.--Lake States white pine area by State, hazard zone, and site index class, 1957

State and hazard zone	Proportion of area in stratum by site index--					
	Total	40	50	60	70	80
Minnesota:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
High	100	22	60	17	1	--
Medium	100	9	34	45	12	--
Wisconsin:						
High	100	15	36	42	6	1
Medium	100	--	22	41	28	9
Low	100	--	10	38	45	7
Michigan:						
High	100	23	25	42	10	--
Low	100	4	29	46	19	2
High	100	19	38	36	6	1
Medium	100	4	28	43	20	5
Low	100	3	23	43	27	4
Lake States	100	10	30	40	17	3

TABLE 7.--Lake States white pine area with pine stands less than 50 years old by site index class and hazard zone, 1957

Site index class	Rust-hazard zone			
	All zones	High	Medium	Low
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
40	89	74	6	9
50	241	121	51	69
60	358	117	74	167
70	176	29	46	101
80	27	3	13	11
Total	891	344	190	357

TABLE 8.--Present gross volume of scattered sawtimber-size white pines in white pine stands less than 50 years old, by site index class and hazard zone, 1957

Site index class	Rust-hazard zone			
	All zones	High	Medium	Low
	Million board feet	*Million board feet*	*Million board feet*	*Million board feet*
40	27	19	3	5
50	133	81	32	20
60	195	61	59	75
70	88	1	54	33
80	14	1	12	1
Total	457	163	160	134

TABLE 9.--Present gross volume of white pine sawtimber in white pine stands 50 years and older, by site index class and hazard zone, 1957

Site index class	Rust-hazard zone			
	All zones	High	Medium	Low
	Million board feet	*Million board feet*	*Million board feet*	*Million board feet*
40	272	200	43	29
50	1,140	590	227	323
60	1,212	579	369	264
70	282	21	85	176
80	59	--	--	59
Total	2,965	1,390	724	851

TABLE 10.--Cost of one man-day of rust control work including margin for risk and 3.0 and 3.5 percent compound interest by number of future workings required and length of investment period

3.0 PERCENT INTEREST

Future workings (number)	Cost based on investment period, in years--								
	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120
One..............	$98	$132	$178	$239	$321	$432	$580	$780	$1,048
Two..............	93	125	168	226	304	408	549	737	991
Three............	90	121	162	218	293	393	529	710	955
Four.............	87	118	158	212	285	384	515	693	931
3.5 PERCENT INTEREST									
One..............	$117	$165	$232	$327	$462	$652	$919	$1,297	$1,829
Two..............	109	154	218	307	433	611	862	1,216	1,715
Three............	105	148	209	294	415	585	826	1,165	1,643
Four.............	102	144	203	286	403	569	802	1,132	1,596

Note: These costs at time of harvest per man-day assume a cost of $28 plus a 25-percent risk factor, or $35; that each working required one-half the labor required for the preceding working; and a risk-free compound interest rate as indicated. If preferred, one of these may be substituted for the cost table based on 2.5-percent interest on the "Calculation Aid."

TABLE 11.--Anticipated gross volume, number of merchantable trees, average d.b.h. and merchantable length of merchantable trees in thinned and unthinned white pine stands at time of harvest by site index, rotation age, and present pine stocking

SITE INDEX 40

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 80, unthinned:	*Board feet*	*Number*	*Inches*	*Feet*
1-6	2,622	28	11.6	41
7-13	4,489	61	11.0	36
14-19	5,944	96	10.6	33
20-26	6,852	123	10.3	31
27-32	7,496	142	10.2	30
33-39	7,550	144	10.2	30
40-45	7,605	145	10.2	30
46-52	7,659	147	10.2	30
53-58	7,714	148	10.2	30
59-65	7,768	150	10.2	30
Rotation age 100, unthinned:				
1-6	6,398	56	12.8	47
7-13	7,926	77	12.4	45
14-19	10,392	121	11.8	41
20-26	11,948	153	11.6	39
27-32	12,952	187	11.2	37
33-39	13,220	196	11.1	36
40-45	13,492	206	11.0	35
46-52	13,765	215	11.0	35
53-58	14,043	225	10.9	34
59-65	14,312	234	10.8	34
Rotation age 120, unthinned:				
1-6	10,198	71	13.5	51
7-13	11,270	84	13.3	50
14-19	12,342	98	13.0	48
20-26	13,414	112	12.8	47
27-32	14,486	126	12.7	46
33-39	15,557	145	12.4	45
40-45	16,629	166	12.2	44
46-52	17,701	187	12.0	42
53-58	18,773	218	11.7	40
59-65	19,845	253	11.4	37
Rotation age 120, thinned:				
53-58	18,038	194	11.9	42
59-65	18,038	194	11.9	42

See footnotes at end of table.

TABLE 11.--Continued

SITE INDEX 50

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 80, unthinned:	*Board feet*	*Number*	*Inches*	*Feet*
1-6	4,091	29	13.3	53
7-11	7,134	64	12.5	47
12-17	9,626	103	11.9	43
18-23	11,313	135	11.6	40
24-28	12,620	169	11.2	38
29-34	13,503	196	11.0	36
35-40	14,029	215	10.9	36
41-45	14,365	222	10.8	35
46-51	14,487	226	10.8	34
52-57	14,509	227	10.8	34
Rotation age 100, unthinned:				
1-6	12,585	69	13.9	58
7-11	15,384	92	13.6	56
12-17	19,904	146	12.8	52
18-23	22,591	191	12.2	48
24-28	24,174	229	11.8	44
29-34	24,364	234	11.8	44
35-40	24,554	239	11.7	43
41-45	24,744	244	11.7	43
46-51	24,934	250	11.6	43
52-57	25,124	255	11.6	42
Rotation age 100, thinned:				
18-23	21,623	175	12.4	47
24-28	21,623	175	12.4	47
29-34	21,623	175	12.4	47
35-40	21,623	175	12.4	47
41-45	21,623	175	12.4	47
46-51	21,623	175	12.4	47
52-57	21,623	175	12.4	47
Rotation age 120, unthinned:				
1-6	14,089	52	15.7	69
7-11	22,314	107	14.4	60
12-17	28,156	164	13.5	57
18-23	31,005	211	13.3	51
24-28	31,260	216	12.8	51
29-34	31,514	226	12.6	50
35-40	31,769	233	12.5	49
41-45	32,344	249	12.3	47
46-51	32,513	253	12.3	47
52-57	32,532	254	12.3	47

See footnotes at end of table.

TABLE 11.--Continued

SITE INDEX 60--Continued

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 100, thinned:	*Board feet*	*Number*	*Inches*	*Feet*
15-19	32,405	118	15.4	70
20-24	32,405	118	15.4	70
25-29	32,405	118	15.4	70
30-33	32,405	118	15.4	70
34-38	32,405	118	15.4	70
39-43	32,405	118	15.4	70
44-48	32,405	118	15.4	70
Rotation age 120, unthinned:				
1-5	17,641	34	18.9	91
6-10	28,689	68	17.6	84
11-14	37,193	103	16.7	79
15-19	42,108	128	16.1	75
20-24	45,519	147	15.7	73
25-29	48,022	169	15.3	71
30-33	49,844	188	14.9	69
34-38	51,311	204	14.6	67
39-43	52,334	216	14.4	65
44-48	53,176	236	14.0	62
Rotation age 120, thinned:				
11-14	37,040	102	16.7	79
15-19	37,040	102	16.7	79
20-24	37,040	102	16.7	79
25-29	37,040	102	16.7	79
30-33	37,040	102	16.7	79
34-38	37,040	102	16.7	79
39-43	37,040	102	16.7	79
44-48	37,040	102	16.7	79

SITE INDEX 70

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 80, unthinned:	*Board feet*	*Number*	*Inches*	*Feet*
1-4	8,991	22	17.8	85
5-8	16,230	46	16.8	80
9-12	23,861	78	15.9	74
13-16	27,595	99	15.4	70
17-20	31,873	126	15.0	67
21-25	35,311	153	14.5	63
26-29	38,006	180	14.2	61
30-33	40,359	204	13.4	60
34-37	42,178	233	12.9	57
38-42	43,809	271	12.4	53

See footnotes at end of table.

TABLE 11.--Continued

SITE INDEX 70--Continued

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 80, thinned:	*Board feet*	*Number*	*Inches*	*Feet*
21-25	32,373	130	14.9	66
26-29	32,373	130	14.9	66
30-33	32,373	130	14.9	66
34-37	32,373	130	14.9	66
38-42	32,373	130	14.9	66
Rotation age 100, unthinned:				
1-4	15,317	23	20.1	97
5-8	25,964	48	18.8	92
9-12	34,965	78	17.9	87
13-16	41,353	98	17.2	84
17-20	46,103	118	16.8	81
21-25	49,849	134	16.4	79
26-29	52,824	157	15.9	76
30-33	55,455	179	15.4	73
34-37	57,523	200	15.0	71
38-42	59,398	235	14.3	65
Rotation age 100, thinned:				
13-16	40,558	95	17.3	85
17-20	40,558	95	17.3	85
21-25	40,558	95	17.3	85
26-29	40,558	95	17.3	85
30-33	40,558	95	17.3	85
34-37	40,558	95	17.3	85
38-42	40,558	95	17.3	85
Rotation age 120, unthinned:				
1-4	20,800	24	21.6	111
5-8	34,307	49	20.2	100
9-12	45,089	75	19.1	95
13-16	51,742	95	18.5	92
17-20	56,684	112	18.0	90
21-25	60,644	128	17.6	87
26-29	63,766	145	17.1	84
30-33	66,489	161	16.7	82
34-37	68,679	180	16.2	79
38-42	70,658	209	15.8	73

See footnotes at end of table.

TABLE 11.--Continued

SITE INDEX 70--Continued

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 120, thinned:	*Board feet*	*Number*	*Inches*	*Feet*
13-16	45,777	77	19.1	95
17-20	45,777	77	19.1	95
21-25	45,777	77	19.1	95
26-29	45,777	77	19.1	95
30-33	45,777	77	19.1	95
34-37	45,777	77	19.1	95
38-42	45,777	77	19.1	95

SITE INDEX 80

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 80, unthinned:	*Board feet*	*Number*	*Inches*	*Feet*
1-3	9,431	16	20.1	103
4-7	17,431	35	18.9	97
8-11	26,199	61	18.0	92
12-15	30,989	79	17.4	88
16-19	36,558	103	16.8	85
20-23	41,384	126	16.4	82
24-27	45,455	151	15.9	79
28-31	49,278	179	15.4	76
32-35	52,512	210	14.9	72
36-39	55,637	266	14.0	65
Rotation age 80, thinned:				
20-23	41,149	125	16.4	83
24-27	41,149	125	16.4	83
28-31	41,149	125	16.4	83
32-35	41,149	125	16.4	83
36-39	41,149	125	16.4	83
Rotation age 100, unthinned:				
1-3	17,339	19	22.7	112
4-7	29,677	39	21.3	112
8-11	40,350	61	20.3	108
12-15	48,176	81	19.6	104
16-19	54,217	99	19.0	101
20-23	57,121	117	18.5	98
24-27	63,230	135	18.0	95
28-31	66,990	154	17.5	91
32-35	70,121	175	16.9	88
36-39	73,060	214	15.9	79

See footnotes at end of table.

TABLE 11.--Continued

SITE INDEX 80--Continued

Rotation age, crop trees per 0.1 acre, and thinning treatment	Gross volume at harvest[1]	Merchantable trees[2]	Average d.b.h. of merchantable trees	Average merchantable height of merchantable trees
Rotation age 100, thinned:	*Board feet*	*Number*	*Inches*	*Feet*
16-19	48,737	83	19.5	104
20-23	48,737	83	19.5	104
24-27	48,737	83	19.5	104
28-31	48,737	83	19.5	104
32-35	48,737	83	19.5	104
36-39	48,737	83	19.5	104
Rotation age 120, unthinned:				
1-3	18,943	16	24.6	112
4-7	31,247	28	23.7	112
8-11	42,552	42	23.0	112
12-15	54,856	60	22.0	112
16-19	66,160	72	21.1	112
20-23	72,465	80	20.6	112
24-27	77,769	93	20.2	109
28-31	80,073	108	19.8	106
32-35	82,378	134	18.9	100
36-39	84,682	187	17.1	88
Rotation age 120, thinned:				
16-19	55,939	72	21.1	112
20-23	55,939	72	21.1	112
24-27	55,939	72	21.1	112
28-31	55,939	72	21.1	112
32-35	55,939	72	21.1	112
36-39	55,939	72	21.1	112

[1]Gross board-foot volume of expected yield per acre at harvest if the area is fully occupied by pine.

[2] Number of merchantable trees at harvest 9 inches d.b.h. or larger.

Note: In certain stand situations (e.g., low stocking percent, short rotation age, and low site index) stands will not require thinning by rotation age. In these circumstances, when thinning is not applicable, no statistics are presented for "thinned" stands. When thinning is applicable, statistics for thinned stands are shown. Thinning is assumed to be to an "optimum" level (i.e., thinning to maximize annual board-foot increment), and the volume of thinnings is given by the difference between "thinned" and "unthinned" volume.

TABLE 12.--Weevil damage merchantable-length factors

Average merchantable length (feet)	Factor[1]	Average merchantable length (feet)	Factor[1]
4	4.0	64	33.3
8	8.0	68	34.1
12	12.0	72	34.9
16	16.0	76	35.7
20	18.0	80	36.5
24	20.0	84	37.2
28	22.0	88	37.9
32	24.0	92	38.5
36	25.3	96	39.2
40	26.7	100	39.8
44	28.0	104	40.3
48	29.3	108	40.9
52	30.3	112	41.5
56	31.3	116	42.0
60	32.3	120	42.5

[1] Merchantable-length factors are used in a weighting system devised to account for differences in volume loss due to weevil injuries at different heights in white pine trees. For a full explanation of these factors see page 15.

TABLE 13.--Lake States white pine area with stands less than 50 years old by rust-hazard zone, State, and selected stocking conditions, 1957

State and rust hazard zone	Total area with stands less than 50 years	Stocked but no release required	Less than 50 suppressed pine per acre	50 or more suppressed pines per acre by primary type of competition			
				Best hardwoods[1]	Inferior hardwoods[2]	Red pine	Conifers other than red and white pine[3]
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
High:							
Minnesota.............	40	9	22	--	3	4	2
Wisconsin.............	183	33	82	8	46	11	3
Michigan..............	121	22	58	--	9	19	13
Medium:							
Minnesota.............	82	17	30	4	14	4	13
Wisconsin.............	108	30	26	--	35	2	15
Low:							
Minnesota.............	1	1	--	--	--	--	--
Wisconsin.............	98	10	44	--	40	--	4
Michigan..............	258	48	67	33	102	5	3
Total high..............	344	64	162	8	58	34	18
Total medium............	190	47	56	4	49	6	28
Total low...............	357	59	111	33	142	5	7
Lake States..........	891	170	329	45	249	45	53

1 Non-cull trees of northern red oak, basswood, yellow birch, and Wisconsin and Michigan sugar maple.
2 All hardwoods other than above including culls.
3 Primarily balsam fir, spruce, and hemlock.

TABLE 14.--Number of quality index points added to base index for improved quality due to pruning by rotation age, stocking class, and site index[1]

SITE INDEX 40--UNTHINNED

Rotation age	Points added, based on percent stocking at age 50--									
	10	20	30	40	50	60	70	80	90	100
80...............	18	15	13	11	10	10	10	10	10	10
100...............	25	24	21	19	17	17	17	17	16	15
120...............	25	25	25	23	21	20	19	18	17	17
SITE INDEX 40--THINNED										
80...............	--	--	--	--	--	--	--	--	--	--
100...............	--	--	--	--	--	--	--	--	--	--
120...............	--	--	--	--	--	--	--	--	17	17
SITE INDEX 50--UNTHINNED										
80...............	26	24	22	19	18	17	17	16	16	16
100...............	24	24	19	17	17	17	17	16	16	16
120...............	25	24	19	17	17	17	17	17	17	17
SITE INDEX 50--THINNED										
80...............	--	--	--	--	--	--	--	--	--	--
100...............	--	--	--	18	18	18	18	18	18	18
120...............	--	--	20	20	20	20	20	20	20	20
SITE INDEX 60--UNTHINNED										
80...............	25	25	25	24	19	18	17	17	17	16
100...............	24	24	24	21	19	18	17	17	17	17
120...............	24	24	24	21	19	19	18	17	17	17
SITE INDEX 60--THINNED										
80...............	--	--	--	--	--	19	19	19	19	19
100...............	--	--	--	22	22	22	22	22	22	22
120...............	--	--	24	24	24	24	24	24	24	24
SITE INDEX 70--UNTHINNED										
80...............	28	27	26	25	23	20	19	18	17	17
100...............	24	25	25	24	23	21	19	19	18	18
120...............	23	24	24	24	23	21	20	19	19	18
SITE INDEX 70--THINNED										
80...............	--	--	--	--	--	22	22	22	22	22
100...............	--	--	--	25	25	25	25	25	25	25
120...............	--	--	--	24	24	24	24	24	24	24

See footnote at end of table.

TABLE 14.--Continued

SITE INDEX 80--UNTHINNED

Rotation age	Points added, based on percent stocking at age 50--									
	10	20	30	40	50	60	70	80	90	100
80..............	27	27	28	27	27	24	22	20	19	18
100..............	24	25	25	26	25	24	22	21	20	19
120..............	24	24	24	24	24	24	24	24	21	19
SITE INDEX 80--THINNED										
80..............	--	--	--	--	--	24	24	24	24	24
100..............	--	--	--	--	26	26	26	26	26	26
120..............	--	--	--	--	24	24	24	24	24	24

[1] For derivation of these data, see page 19.

TABLE 15.--Total area in Lake States white pine stands under 50 years old and area on which selected management treatments are applicable, by hazard zone and State, 1957

Hazard zone and State	Total area	Area on which treatments are applicable							
		Weevil control		Release		Thinning		Pruning	
	M acres	*Percent*	*M acres*	*Percent*	*M acres*	*Percent*	*M acres*	*Percent*	*M acres*
High:									
Minnesota......	40	39	16	77	31	23	9	94	38
Wisconsin......	183	39	71	82	150	51	94	92	168
Michigan.......	121	36	44	82	99	30	36	93	112
Medium:									
Minnesota......	82	60	49	80	65	58	47	87	71
Wisconsin......	108	50	54	72	78	50	54	94	102
Low:									
Minnesota......	1	100	1	0	0	0	0	100	1
Wisconsin......	98	67	66	89	88	30	29	100	98
Michigan.......	258	59	152	81	210	53	138	94	243
High............	344	38	131	81	280	40	139	93	318
Medium...........	190	54	103	75	143	53	101	91	173
Low.............	357	61	219	83	298	47	167	96	342
Lake States..	891	51	453	81	721	46	407	93	833

TABLE 16.--Thinning factors[1]

Site index and rotation age	Percent Stocking									
	10	20	30	40	50	60	70	80	90	100
Site 40:										
80...........	--	--	--	--	--	--	--	--	--	--
100...........	--	--	--	--	--	--	--	--	--	--
120...........	--	--	--	--	--	--	--	--	423	1,138
Site 50:										
80...........	--	--	--	--	--	--	--	--	--	--
100...........	--	--	--	558	1,607	1,727	1,847	1,966	2,086	2,205
120...........	--	--	1,601	3,720	4,294	4,485	4,681	5,121	5,246	5,263
Site 60:										
80...........	--	--	--	--	--	339	1,343	2,151	2,969	3,476
100...........	--	--	--	769	2,918	4,920	6,155	7,146	8,639	9,268
120...........	--	--	88	3,496	6,449	9,307	10,857	12,100	13,993	14,762
Site 70:										
80...........	--	--	--	--	--	1,692	3,507	5,032	6,764	7,891
100...........	--	--	--	458	3,493	6,410	9,329	11,330	14,384	15,972
120...........	--	--	--	4,117	9,250	12,609	16,458	18,953	23,648	25,696
Site 80:										
80...........	--	--	--	--	--	136	2,713	5,610	7,841	9,996
100...........	--	--	--	--	3,452	7,164	11,022	15,477	18,129	20,625
120...........	--	--	--	--	7,774	14,008	19,971	24,917	27,294	29,671

[1] Thinning factors represent thinning volume expressed in terms of harvest volume and take into account differences among multiple thinnings in quality, price level, and time of thinning. These factors are used in computing value of thinnings saved by blister rust control. No factor is shown for stand conditions that will not produce sufficient volume to support thinnings. Derivation of factors is discussed on page 30.

TABLE 17.--Lake States white pine blister rust control area by rust-hazard zone and State, and by selected stocking and rust control conditions, 1957

Rust-hazard zone and State	Total white pine area in the BR control area	Stands 50+ years old	Stands less than 50 years old: Total area	Stands less than 50 years old: Area with no free-growing pine but some suppressed pine[1]	Stands less than 50 years old: Area needing no future BRC treatment	Stands less than 50 years old: Area needing future BRC treatment
	M acres	*M acres*	*M acres*	*M acres*	*M acres*	*M acres*
High:						
Minnesota...........	105	65	40	2	10	28
Wisconsin...........	277	94	183	--	47	136
Michigan............	146	25	121	6	60	55
Medium:						
Minnesota...........	127	45	82	3	10	69
Wisconsin...........	144	36	108	3	64	41
Low:						
Minnesota...........	1	--	1	--	1	--
Wisconsin...........	132	34	98	18	69	11
Michigan............	314	56	258	13	106	139
Total high............	528	184	344	8	117	219
Total medium..........	271	81	190	6	74	110
Total low.............	447	90	357	31	176	150
Lake States.......	1,246	355	891	[1] 45	367	479

[1] If suppressed pines are released, 15,000 of the 45,000 acres will also need rust control treatment.

TABLE 18.--Potential gross volume of white pine at maturity[1] in existing Lake States white pine stands, by selected management treatments where applicable and hazard zone

Area and treatment	Hazard zone			
	All zones	High	Medium	Low
	Million board feet	*Million board feet*	*Million board feet*	*Million board feet*
Stands now 50+ years old.........	6,098	2,792	1,491	1,815
Scattered sawtimber in stands now under 50 years old.........	1,472	562	478	432
Stands now under 50 years old:				
No treatment..................	11,113	3,215	2,407	5,491
Rust control only..............	13,628	4,989	2,955	5,684
Rust and weevil control........	14,044	5,112	2,992	5,940
Rust control plus release......	16,739	5,755	3,696	7,288
All treatments.................	17,286	5,911	3,724	7,651
Total all areas:				
No treatment..................	18,683	6,569	4,376	7,738
Rust control only..............	21,198	8,343	4,924	7,931
Rust and weevil control........	21,614	8,466	4,961	8,187
Rust control plus release......	24,309	9,109	5,665	9,535
All treatments.................	24,856	9,265	5,693	9,898

[1] For rotation ages used, see page 33.

TABLE 19.--Potential value of white pine at maturity in existing Lake States white pine stands, by selected management treatments where applicable and hazard zone

Area and treatment	Hazard zone			
	All zones	High	Medium	Low
	Million dollars	*Million dollars*	*Million dollars*	*Million dollars*
Stands now 50+ years old.........	165	76	40	49
Scattered sawtimber in stands now under 50 years old.........	40	15	13	12
Stands now under 50 years old:				
No treatment..................	504	151	110	243
Rust control only.............	623	234	137	252
Rust and weevil control........	657	242	146	269
Rust control plus release......	760	270	173	317
All treatments................	1,702	585	374	743
Total all areas:				
No treatment..................	709	242	163	304
Rust control only.............	828	325	190	313
Rust and weevil control........	862	333	199	330
Rust control plus release......	965	361	226	378
All treatments................	1,907	676	427	804

TABLE 20.--Potential gross volume of white pine at maturity in Lake States white pine stands now under 50 years old, by hazard zone and State and by selected management treatments where applicable

Hazard zone and State	Rust control only			Rust and weevil control			Rust control plus release			All treatments[1]		
	No BRC needed	BRC needed		No BRC needed	BRC needed		No BRC needed	BRC needed		No BRC needed	BRC needed	
		Without BRC	With BRC		Without BRC	With BRC		Without BRC	With BRC		Without BRC	With BRC
	Million board feet	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*
High:												
Minnesota.......	68	115	277	70	117	281	77	125	306	80	115	282
Wisconsin.......	757	1,113	2,409	774	1,131	2,451	869	1,195	2,755	804	1,120	2,476
Michigan........	865	297	613	912	303	624	1,020	352	728	1,000	345	713
Medium:												
Minnesota.......	111	723	1,055	112	733	1,069	141	812	1,188	138	727	1,058
Wisconsin.......	1,014	559	775	1,031	561	780	1,448	658	919	1,215	549	763
Low:												
Wisconsin.......	939	85	91	963	87	94	1,393	162	172	1,226	162	172
Michigan........	1,959	2,508	2,695	2,062	2,624	2,821	2,324	3,161	3,399	2,263	2,984	3,206
High.............	1,690	1,525	3,299	1,756	1,551	3,356	1,966	1,672	3,789	1,884	1,580	3,471
Medium...........	1,125	1,282	1,830	1,143	1,294	1,849	1,589	1,470	2,107	1,353	1,276	1,821
Low..............	2,898	2,593	2,786	3,025	2,711	2,915	3,717	3,323	3,571	3,489	3,146	3,378
Lake States...	5,713	5,400	7,915	5,924	5,556	8,120	7,272	6,465	9,467	6,726	6,002	8,670

[1] Final harvest only. With thinnings included, Lake States totals become 7,541, 6,744, and 9,745.

TABLE 21.--Potential gross volume of white pine at maturity that could be profitably and unprofitably saved by blister rust control in Lake States stands now under 50 years old, by hazard zone and State and by selected management treatments where applicable

Hazard zone and State	Rust control only			Rust plus weevil control			Rust control plus release			All treatments[1]		
	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable
	Million board feet	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*
High:												
Minnesota......	162	100	62	164	116	48	181	115	66	167	139	28
Wisconsin......	1,296	1,274	22	1,320	1,298	22	1,560	1,543	17	1,356	1,351	5
Michigan.......	316	283	33	321	286	35	376	352	24	368	362	6
Medium:												
Minnesota......	332	242	90	336	244	92	376	279	97	331	314	17
Wisconsin......	216	183	33	219	186	33	261	261	--	214	214	--
Low:												
Wisconsin......	6	--	6	7	--	7	10	7	3	10	7	3
Michigan.......	187	151	36	197	164	33	238	201	37	222	215	7
High............	1,774	1,657	117	1,805	1,700	105	2,117	2,010	107	1,891	1,852	39
Medium..........	548	425	123	555	430	125	637	540	97	545	528	17
Low.............	193	151	42	204	164	40	248	208	40	232	222	10
Lake States..	2,515	2,233	282	2,564	2,294	270	3,002	2,758	244	2,668	2,602	66

[1] Final harvest only. With thinnings included Lake States totals become 3,001, 2,928, and 74.

TABLE 22.--Potential gross volume and value of white pine at maturity in Lake States white pine stands now less than 50 years old by hazard zone and State and by final harvest and thinnings[1]

Hazard zone and State	Total		Final harvest		Intermediate thinnings	
	Volume	Value	Volume	Value	Volume	Value
	Million board feet	*Million dollars*	*Million board feet*	*Million dollars*	*Million board feet*	*Million dollars*
High:						
Minnesota......	391	40	362	38	29	2
Wisconsin......	3,686	361	3,280	339	406	22
Michigan.......	1,834	184	1,713	179	121	5
Medium:						
Minnesota......	1,352	135	1,196	126	156	9
Wisconsin......	2,372	238	1,978	217	394	21
Low:						
Wisconsin......	1,597	166	1,398	156	199	10
Michigan.......	6,054	577	5,469	551	585	26
High.............	5,911	585	5,355	556	556	29
Medium...........	3,724	373	3,174	343	550	30
Low..............	7,651	743	6,867	707	784	36
Lake States..	17,286	1,701	15,396	1,606	1,890	95

[1] Assuming all treatments where needed.

TABLE 23.--Area in Lake States white pine stands less than 50 years old which need future rust control treatment, by hazard zone and State, and by profitability of rust control with selected management treatments where applicable

Hazard zone and State	Rust control only			Rust plus weevil control			Rust control plus release			All treatments[1]		
	Total	Profitable	Unprofitable	Total	Profitable	Unprofitable	Total	Profitable	Unprofitable	Total	Profitable	Unprofitable
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
High:												
Minnesota......	28	10	18	28	12	16	30	11	19	30	17	13
Wisconsin......	136	121	15	136	122	14	136	122	14	136	130	6
Michigan.......	55	38	17	55	39	16	58	41	17	58	50	8
Medium:												
Minnesota......	69	35	34	69	36	33	70	40	30	70	58	12
Wisconsin......	41	24	17	41	25	16	41	41	--	41	41	--
Low:												
Wisconsin......	11	--	11	11	--	11	11	4	7	11	4	7
Michigan.......	139	92	47	139	100	39	148	108	40	148	138	10
High............	219	169	50	219	173	46	224	174	50	224	197	27
Medium..........	110	59	51	110	61	49	111	81	30	111	99	12
Low.............	150	92	58	150	100	50	159	112	47	159	142	17
Lake States..	479	320	159	479	334	145	494	367	127	494	438	56

[1] All treatments include those shown plus thinning and pruning where applicable.

TABLE 24.--Potential value of white pine at maturity in Lake States white pine stands now less than 50 years old, by hazard zone and State and by selected management treatments where applicable

Hazard zone and State	Rust control only			Rust plus weevil control			Rust control plus release			All treatments[1]		
	No BRC needed	BRC needed		No BRC needed	BRC needed		No BRC needed	BRC needed		No BRC needed	BRC needed	
		Without BRC	With BRC		Without BRC	With BRC		Without BRC	With BRC		Without BRC	With BRC
	Million dollars	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*
High:												
Minnesota........	3	6	14	4	6	14	4	6	15	7	13	31
Wisconsin........	35	52	113	37	52	115	40	58	130	86	113	253
Michigan.........	41	14	28	43	14	29	48	16	33	105	36	74
Medium:												
Minnesota........	5	30	46	5	35	52	6	39	57	12	77	114
Wisconsin........	48	27	38	50	28	39	66	31	44	136	58	81
Low:												
Wisconsin........	46	4	4	48	4	4	65	7	8	139	16	17
Michigan.........	82	111	120	88	120	129	96	137	148	216	311	335
High...............	79	72	155	84	72	158	92	80	178	198	162	358
Medium.............	53	57	84	55	63	91	72	70	101	148	135	195
Low................	128	115	124	136	124	133	161	144	156	355	327	352
Lake States....	260	244	363	275	259	382	325	294	435	701	624	905

[1] Final harvest only. With value of thinnings included Lake States totals become 741, 663, and 961.

TABLE 25.--Potential value of white pine at maturity that could be profitably and unprofitably saved by blister rust control in Lake States stands now under 50 years old, by hazard zone and State and by selected management treatments where applicable

Hazard zone and State	Rust control only			Rust plus weevil control			Rust control plus release			All treatments[1]		
	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable	Total	Profit-able	Unprof-itable
	Million dollars	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*
High:												
Minnesota......	8	5	3	8	6	2	9	6	3	18	15	3
Wisconsin......	61	60	1	63	62	1	72	71	1	140	140	--
Michigan.......	14	13	1	15	13	2	17	16	1	38	37	1
Medium:												
Minnesota......	16	12	4	17	12	5	18	13	5	37	35	2
Wisconsin......	11	9	2	11	9	2	13	13	--	23	23	--
Low:												
Wisconsin......	--	--	--	--	--	--	1	1	--	1	1	--
Michigan.......	9	7	2	9	7	2	11	9	2	24	23	1
High............	83	78	5	86	81	5	98	93	5	196	192	4
Medium..........	27	21	6	28	21	7	31	26	5	60	58	2
Low.............	9	7	2	9	7	2	12	10	2	25	24	1
Lake States..	119	106	13	123	109	14	141	129	12	281	274	7

[1] Final harvest only. With thinnings included Lake States totals become 298, 291, and 7.

TABLE 26.--Estimated field labor required and cost of establishing blister rust control on Lake States white pine areas in need of additional treatment[1]

State and hazard zone	Total area requiring additional rust control treatment		Area which can be profitably treated	
	Labor	Cost[2]	Labor	Cost[2]
	Thousand man-days	*Thousand dollars*	*Thousand man-days*	*Thousand dollars*
Minnesota:				
High	35	10,433	5	1,751
Medium	51	14,964	26	6,946
Total	86	25,397	31	8,697
Wisconsin:				
High	55	13,110	48	11,737
Medium	20	4,181	9	2,179
Low	12	1,805	--	--
Total	87	19,096	57	13,916
Michigan:				
High	28	7,028	14	3,203
Low	18	5,271	11	2,662
Total	46	12,299	25	5,865
Lake States:				
High	118	30,571	67	16,691
Medium	71	19,145	35	9,125
Low	30	7,076	11	2,662
Total	219	56,792	113	28,478

[1] Assuming immediate treatment of all areas requiring additional rust control measures without other treatments.

[2] Total cost including overhead, margin for risk, and 2.5 percent interest to time of harvest.

APPENDIX B

Field Manual
North Central Region

INSTRUCTIONS FOR EVALUATING THE PROFITABILITY OF BLISTER RUST CONTROL IN INDIVIDUAL STANDS OF LAKE STATES WHITE PINE

June 1960

CONTENTS

General

The profitability of blister rust control in any white pine stand can be judged by comparing the cost of control with the value of the pine saved by control measures. This, however, involves consideration of many factors. The cost of control includes interest on funds invested and, therefore, depends on the number of years until harvest as well as the initial treatment cost. The value of pine saved depends on the price per unit at time of harvest and the number of units or volume saved. The unit price will vary with quality. Both the quality and volume of pine saved will depend on the type of management given the stand as well as on the density and age of the pine, productivity of the site, and length of management rotation.

To aid foresters in evaluating the complex interrelationships of these and other factors affecting the profitability of rust control, three working tools have been developed.

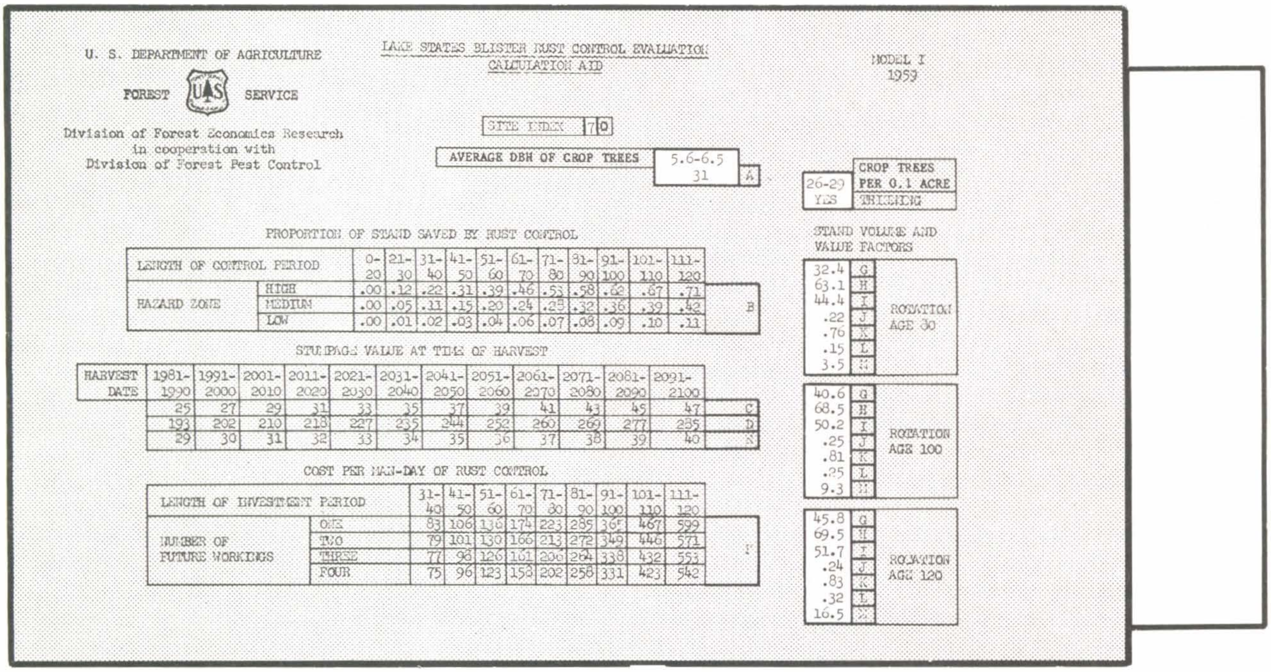
The first is a field plot tally form (EWP-1, attached) for recording data, from sample plots throughout the stand, regarding the stand condition variables required. The second is a combined stand condition summary form (EWP-2, attached) and computation worksheet. The front side provides a summary of sample-plot data and other variables determined in the field for the stand as a whole. The back side is a

computation worksheet which outlines calculations required to evaluate rust control profitability in the stand.

The third working tool is a set of matched data cards identified as "Lake States Blister Rust Control Evaluation Calculation Aid" (fig. B-1). This consists of an outer case with a fitted insert card for each site index class. The Calculation Aid is used somewhat like a slide rule and readily provides results of computations pertaining to potential pine yield, quality, and value, losses caused by blister rust and weevil, rust control costs, and other related factors needed for the calculations of rust control profitability prescribed on the computation worksheet.

yond danger of serious rust losses. Furthermore, sawtimber size pines which become fatally infected can be salvaged. Each stand must be relatively uniform with regard to density, age, and site productivity. If a pine area consists of two or more stands differing greatly in these characteristics, subdivide it into homogeneous stands and evaluate each separately.

In two-storied stands, such as white pine reproduction under white pine sawtimber, decide which age class will predominate under probable management of the area and classify the stand accordingly. For example, if the sawtimber stocking is heavy and not likely to be cut within the next 3 years, the reproduction is unlikely to develop



U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

Division of Forest Economics Research
in cooperation with
Division of Forest Pest Control

LAKE STATES BLISTER RUST CONTROL EVALUATION
CALCULATION AID

MODEL I
1959

SITE INDEX 70

AVERAGE DBH OF CROP TREES: 5.6-6.5 / 31 — A

CROP TREES PER 0.1 ACRE: 26-29 — THINNING: YES

PROPORTION OF STAND SAVED BY RUST CONTROL

LENGTH OF CONTROL PERIOD		0-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
HAZARD ZONE	HIGH	.00	.12	.22	.31	.39	.46	.53	.58	.62	.67	.71	B
	MEDIUM	.00	.05	.11	.15	.20	.24	.25	.32	.36	.39	.42	
	LOW	.00	.01	.02	.03	.04	.06	.07	.08	.09	.10	.11	

STUMPAGE VALUE AT TIME OF HARVEST

HARVEST DATE	1981-1990	1991-2000	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2051-2060	2061-2070	2071-2080	2081-2090	2091-2100	
	25	27	29	31	33	35	37	39	41	43	45	47	C
	193	202	210	218	227	235	244	252	260	269	277	285	D
	29	30	31	32	33	34	35	36	37	38	39	40	N

COST PER MAN-DAY OF RUST CONTROL

LENGTH OF INVESTMENT PERIOD		31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
NUMBER OF FUTURE WORKINGS	ONE	83	106	136	174	223	285	365	467	599	F
	TWO	79	101	130	166	213	272	349	446	571	
	THREE	77	98	126	161	206	264	338	432	553	
	FOUR	75	96	123	158	202	258	331	423	542	

STAND VOLUME AND VALUE FACTORS

	ROTATION AGE 80	ROTATION AGE 100	ROTATION AGE 120
G	32.4	40.6	45.8
H	63.1	68.5	69.5
I	44.4	50.2	51.7
J	.22	.25	.24
K	.76	.81	.83
L	.15	.25	.32
M	3.5	9.3	16.5

Figure B-1.--Lake States Blister Rust Control Evaluation Calculation Aid.

Procedures to be followed in evaluating the profitability of blister rust control in individual stands of Lake States white pine are outlined below.

Field Procedure

Stands to be evaluated

Apply these procedures only in stands of white pine less than sawtimber size. With the relatively short rotations assumed in this analysis, sawtimber stands in the Lake States generally are considered beyond danger of serious rust losses. Furthermore, ...

and so will be ignored. On the other hand, if the sawtimber is likely to be cut within 3 years, base the evaluation of rust control profitability on the stand of reproduction.

Before undertaking a detailed evaluation of rust control profitability in any stand, make certain that additional rust control measures are needed. Many stands need no treatment because of past treatment, absence of ribes, or microclimatic conditions that limit blister rust damage. After initial scouting, proceed with the detailed appraisal of rust control costs and profitability only in stands which need additional control measures.

Rust control costs

Systematically scout the stand and estimate future rust control costs on the white pine area including the protection zone. Observe and consider the following important factors on which control costs depend: (1) Ribes abundance and distribution, (2) whether or not bushes are producing fruit, (3) ribes species, (4) ribes types, (5) type and abundance of associated brush, (6) accessibility, and (7) topography. Map the locations of ribes types and portions of the area that require crew work and scout work. From permanent records obtain actual man-days per acre spent in eradicating ribes under similar conditions.

You now have the basis for estimating costs of the next working. Also estimate control costs for other future workings. The need and extent of subsequent workings depend on: (1) Abundance of fruiting ribes bushes, (2) time between workings, and (3) age of stand and degree of canopy closure. When fruiting bushes are pulled or chemically treated, the exposed seeds in duff germinate and produce new bushes. These bushes, in turn, produce fruit in about 7 years. Therefore if a second working is needed, it should be planned within 6 years so as to find and destroy new ribes bushes after they are large enough to be plainly visible, and before they produce fruit. Usually the second working requires about one-half as much labor as the initial working. If thorough and timely work is done, two workings should reduce the ribes potential to a control maintenance basis. Where fruiting ribes are not abundant and the crown canopy is closing, many stands can be put on maintenance after one working.

The number of future workings needed to establish control and the man-day requirements per acre of pine area for all future workings are stand estimates. Record these figures on the stand summary form EWP-2 for each stand.

Number of plots in a stand

The number of plots needed in each white pine stand depends on the size of the area and the density of pine. Acreage of white pine in the stand can be determined from office files if the area was previously mapped, or it can be estimated on the ground.

While scouting the stand to determine rust control costs, make a rough estimate of average pine density in the entire stand. Express this in terms of percent of full stocking--for this purpose, consider 500 well-spaced (about 9 by 9 feet apart) crop trees per acre as full stocking. Estimate density of pine in the stand to the nearest 10 percent of full stocking. This can best be done by roughly counting crop trees with about 9- by 9-foot spacing on sample 1/10-acre plots (radius 37.25 feet) throughout the stand. Since 50 pines per 1/10-acre is full stocking, an average of 10 per plot, for example, would indicate 20 percent and 15 per plot would indicate 30 percent stocking.

After the density and acreage of white pine in the stand have been roughly estimated, determine the number of plots required for the detailed evaluation of rust control profitability by applying the following data:

Acres of white pine in the stand	Plots required, with stocking percent--			
	10	20	30	40
Less than 20 - - - -	15	12	12	10
20-39 - - - - - -	20	15	12	10
40-99 - - - - - -	25	20	15	12
100-199- - - - - -	30	25	20	15
200 plus - - - - -	35	30	25	15

Location of plots

Plots in each stand should be well distributed and located without personal bias. To achieve this, distribute the required number of plots with centers at equal intervals along parallel lines across the stand drainage, at intervals of 5 to 15 chains depending on the size of pine area, as follows:

On areas of:	Distance between lines (chains)
Less than 150 acres - -	5
150 to 300 acres- - - - -	10
More than 300 acres - -	15

To compute the distance between plot centers along these lines, add the lengths of all lines required to grid the entire pine area at intervals indicated above, and divide this total line length by the number of plots required (from preceding section). The center of the first plot on each line will be located at half of this distance from the stand boundary.

Locate sample plots by hand compass and pacing. Exact location of plots is not vital, provided no personal bias is involved. Once the interval is established, locate plot centers at the predetermined distance as paced off, regardless of the type of forest cover on these spots. Complete a plot tally form at each point even though some plots contain no pine. Including non-stocked plots in computations of average stand conditions makes proper allowance for voids in the pine stand.

Sample plot size

Stand characteristics will be determined on circular 1/10-acre plots--radius 37.25 feet. A borderline tree will be included in the plot tally if more than half of the bole at breast height is in the plot.

Determining and recording field data

Field data will be recorded on the two forms. Data for sample plots will be tallied on the plot tally form (EWP-1), and data regarding variables that apply to the stand as a whole will be summarized on the stand summary and computation form (EWP-2).

Probable future management--The volume and value of pine saved by rust control in any stand depend much on what other management treatments are applied. The evaluation procedure includes consideration of the effects of weevil control, release, thinning, and pruning. Before taking the plot tallies, decide what type of future management the stand is likely to receive, by owner interview or by procedure based on class of landownership provided by the project supervisor. Record these decisions by circling "no" or "yes" for each management treatment listed in items 2-5 on the back of form EWP-2. In deciding, consider weevil control impractical in stands averaging more than 3 inches d.b.h. and pruning impractical in stands more than 6 inches d.b.h. In such places record "no" treatment regardless of the owner's desires or other classification system used.

Site index--Average site index of the stand will be recorded as one of five 10-foot classes from 40 to 80. Site index will be determined on the first plot where suitable pines are encountered. This reading will be checked on at least one other plot in stands where site appears uniform throughout, and more often where ground and cover conditions indicate a possible difference in site.

Determine site index by standard age-height procedure wherever suitable large pines are available. These must be relatively unweeviled dominant or codominant white pines at least 25 years of age and showing no evidence of past suppression. Determine age and height of two suitable pines on or adjacent to the plot and read the corresponding site index for each from the attached Site Index Graph--Second Growth White Pine (fig. B-2). If the two readings do not differ by more than 10 feet, record the 10-foot site index indicated by their average. If they differ by more than 10 feet, include a third sample tree and record the average of the three readings, rounded to the nearest 10-foot class, in the space provided on the front of form EWP-2.

In seedling and sapling areas where no suitable pines more than 25 years old are available, base site index on juvenile pines as follows. Select the three unweeviled dominant or codominant juvenile pines closest to plot center. Determine their respective ages by allowing 8 years for growth to breast height and counting branch whorls from that point to tips of leaders. Determine total height of tall trees by Abney level and of small trees by a folding pocket rule or pole of known length. Also determine and record the diameter of each sample juvenile to the nearest 0.1 inch at a point one-tenth of the total height above ground.

Determine site index by applying these age, diameter, and height data to the attached Site Index Table for Juvenile Eastern White Pine (table B-1). If the three readings do not vary by more than 10 feet, record the 10-foot site index indicated by their average. If variance is greater than 10 feet, measure two additional juveniles and record the site index indicated by the average of the five readings. Here again, if no suitable pines are on the plot, nearby trees may be used.

Pine stocking--On each sample plot, select the white pine crop trees and tally each by recording d.b.h. to the nearest 0.1 on form EWP-1. Tally all pine crop trees with d.b.h. less than 1.0 as 0.5 inch. Include as crop trees only well-spaced pines at about the spacing indicated for each site in the following tabulation. Additional pines between these crop trees have little chance of contributing to the harvest and so will be ignored.

Site index:	Average spacing of crop trees (ft.)	Maximum no. of crop trees per 0.1 acre
40 ----	8 x 8	65
50 ----	9 x 9	57
60 ----	10 x 9	48
70 ----	10 x 10	42
80 ----	11 x 10	39

In selecting crop trees, do not apply rigid standards for distance between trees. As commonly practiced in thinning operations, the prescribed interval between trees can vary somewhat, provided the resulting stand averages the proper spacing. In two-storied stands showing a considerable gap in size and age of trees between the two stories, tally only trees in the broad age group selected for evaluation; ignore those in the other stand.

Before starting the crop tree tally, consider the treatments likely to be applied in future management of the stand. If no release is anticipated, tally only free-growing pines that can be expected to develop into the mature stand unassisted by stand improvement measures. If release is anticipated, the tally will also include properly spaced suppressed pines. These are overtopped pines which are likely to die if not released, or at best survive as suppressed trees contributing little to the mature stand.

In judging the class of a pine, consider the crown position of pine and competitors, species of the competition, and site. Classify pines completely overtopped as suppressed trees in need of release. The probable effects of side competition of northern hardwoods on a good moist site will be much more severe than that of aspen, pin cherry, or birch on a drier site. Free-growing and suppressed pines can be classified only by use of judgment on the ground with full consideration of the factors just described.

Exclude from the tally pine seedlings less than 6 inches tall, which often are not fully established. Also exclude pines that are so diseased or deformed that they have no promise of developing into merchantable sawtimber. Do not tally pine fatally infected with rust as free-growing pine. However, if release is anticipated, tally fatally infected pines that are prunable. For this purpose, infected branches showing no discoloration nearer than 5 inches to the tree bole are considered prunable.

Extent of weevil damage--Examine each crop tree tallied and determine the apparent number of times the main stem has been weeviled as indicated by crooks in the bole and multiple branching. Consider as weevil damage any injuries similar to those caused by weevil, regardless of source. Record the number of times weeviled opposite each crop tree entered on the plot tally form EWP-1.

Percent of plot occupied by white pine--Estimate the percent of each plot occupied by white pine; record this in space provided at top of form EWP-1. To prevent over-estimating potential yield, the yield indicated by normal yield tables will be discounted to reflect percent of area not occupied by white pine. For example, if half of a plot supports no white pine, normal yield cannot be expected from that plot no matter what conditions exist on the half occupied by pine. The purpose here is to recognize only relatively large holes in the pine stand. The crop tree tally reflects the occurrence of small holes in the occupied portion of the plot. Accordingly, only 1/100-acre or larger openings will be recognized in judging occupancy by pine. To aid in judging the percent of 1/10-acre plot unoccupied, various dimensions for unoccupied areas are presented below:

Percent of 1/10-acre unoccupied	Diameter of circle in feet	Side of square in feet	Sides of rectangle in feet
10 ----	24	21	15 x 29
20 ----	33	30	21 x 41
30 ----	41	36	26 x 50
40 ----	47	42	30 x 58
50 ----	53	47	33 x 66

Office Computations

Form EWP-1

Complete the plot tally form for each plot by totaling crop tree diameters and number of weevil injuries on each plot. Record these sums in spaces provided near the bottom of the form.

Form EWP-2, front side

Transfer the plot totals, number of crop trees, and percent of area occupied by white pine for all plots in the stand from completed forms EWP-1 to the spaces provided on form EWP-2 in the block

labeled "Summary of Pine Stocking on Sample Plots."

For each plot, determine and record the expected yield at time of harvest if fully occupied by pine. This figure is item G on the Calculation Aid. Instructions for operating the Calculation Aid are given on page B-2. Next, compute and record the estimated gross yield for each plot. This figure is obtained by multiplying the expected yield if fully occupied by the percent of area occupied for each plot.

Add entries for all plots to obtain stand totals for number of pine crop trees, sum of crop-tree diameters, number of weevil injuries, and gross yield.

Make proper entries for all items in the block labeled "Stand Variables." The first two items required--number of future workings needed to establish rust control and number of man-days per acre of pine area needed to complete all future workings--were recorded in the field. Compute the average d.b.h. of crop trees, the average number of pine crop trees per plot, and gross harvest volume per acre as indicated, using data from the opposite summary block.

The final item required is the average number of weevil injuries per foot of pine bole. In the spaces provided, record the total number of weevil injuries and total number of crop trees (from the opposite summary block), and the average total height of crop trees (determined by average d.b.h. and site index in the tabulation below). Complete the calculation of average number of weevil injuries per foot of stem as indicated and record this figure in the space provided.

<u>Average total height (feet) of white pine by average d.b.h. and site index</u>

Average d.b.h. (inches)	*Site index--*				
	40	*50*	*60*	*70*	*80*
0.5 ---	6	6	7	8	8
1.0 ---	8	8	9	10	10
1.5 ---	11	11	12	12	13
2.0 ---	13	14	14	14	15
2.5 ---	16	17	17	17	18
3.0 ---	19	20	21	21	22
4.0 ---	24	25	27	27	28
5.0 ---	30	31	33	33	34
6.0 ---	37	37	38	39	40
7.0 ---	43	43	44	45	46
8.0 ---	50	50	51	52	53
9.0 ---	57	57	57	58	60
10.0 ---	64	64	64	65	68

Form EWP-2, back side

Complete the record of primary variables by filling in uncompleted items 1-13 on the form as follows.

<u>Item 1</u>--Determine rust hazard zone in which plot is located through use of attached map, White Pine Blister Rust Hazard Zones in the Lake States (fig. B-3).

<u>Items 2-5</u>--These were completed prior to making field plot tally.

<u>Item 6</u>--Determine rotation age from the following tabulation on the bases of site index and class of ownership of the plot.

Class of ownership:	*Rotation age, according to site index--*				
	40	*50*	*60*	*70*	*80*
Federal, State, or county ---	120	120	100	100	100
Private -----	100	100	80	80	80

<u>Items 7-13</u>--Transfer these items from stand summary data recorded on the front of form EWP-2.

Complete the calculations outlined on the remainder of the form, using the Calculation Aid developed for this purpose. Make certain the proper insert is used for the site under consideration. Slide the insert through the cover card to a point where the number in opening labeled "Average d.b.h. of crop trees" corresponds to the average d.b.h. entered in item 9 on the form; then read the figure in opening labeled <u>A</u>. This is the normal age of the stand required for item 14.

Similarly, the number or letter in parentheses above each blank provided for entries on the form indicates the item to be entered. Letters refer to data appearing opposite the same letter on the Calculation Aid. Numbers refer to data already entered in corresponding numbered sections of the form. Items <u>B</u> through <u>F</u> are read directly from tables on the Calculation Aid.

Items <u>G</u> through <u>M</u> require proper setting of the card insert. These appear in openings opposite the letters when the insert is adjusted so that the figure in opening labeled "Crop trees per 0.1 acre" agrees with corresponding item 8 on the form, and a "Yes" or "No" in the opening labeled

"Thinning" indicates plans for such treatment. Notice that there are three sets of answers for items G - M, one set for each rotation age. Make certain that you use the proper set. Also notice that where thinning is proposed in stands which cannot produce sufficient volume to support thinnings, the words "Thinning not applicable" appear for all entries G - M. In stands where this occurs, thinning is impractical; shift the insert to "No" thinning for items G - M.

When all calculations outlined on the form are completed, item 23 will show the potential profit or loss per acre, and item 24 the potential return per dollar spent for rust control in the stand.

Form EWP-1

BLISTER RUST CONTROL EVALUATION FORM

Plot Tally Sheet

Area No. ______ Percent of plot occupied by white pine ____ Plot No. _____ of ___

Pine Stocking and Weevil Injuries on 1/10-Acre Sample Plot

Crop tree no.	DBH[1/]	No. of weevil injuries	Crop tree no.	DBH	No. of weevil injuries	Crop tree no.	DBH	No. of weevil injuries
1			23			45		
2			24			46		
3			25			47		
4			26			48		
5			27			49		
6			28			50		
7			29			51		
8			30			52		
9			31			53		
10			32			54		
11			33			55		
12			34			56		
13			35			57		
14			36			58		
15			37			59		
16			38			60		
17			39			61		
18			40			62		
19			41			63		
20			42			64		
21			43			65		
22			44			Totals		

[1/] To nearest 0.1 inch. Record all seedlings less than 1.0 inch d.b.h. as 0.5 inch

Form EWP-2, front side

BLISTER RUST CONTROL EVALUATION FORM

Stand Summary and Computation Sheet

District ____________ County ____________ Area no. _________ No. of plots _____ Date __________ Estimator __________

SITE INDEX

MATURE DOMINANTS

Tree no.	Age	Total height	Site index
Average site index for stand:			________

JUVENILE DOMINANTS

Tree no.	Age	Total height	DBH 1/10 ht.	Site index
Average site index for stand:			__________	

STAND VARIABLES

No. of future workings needed to establish rust control: 1 2 3 4

Man-days per acre of pine area to complete all future workings: ______

Average d.b.h. of crop trees:
(Sum of diameters) (No. pine crop trees)

_________ ÷ __________ = __________

Average no. pine crop trees per plot:
(No. pine crop trees) (No. of sample plots)

_________ ÷ __________ = __________

Gross harvest volume per acre:
(Gross yield) (No. of plots)

_________ ÷ __________ = __________

Weevil injuries per ft. of pine bole:
(Tot.no. injuries) (Av.tree height) (No. pine crop trees)

_____ ÷ (_____ × _____) = ________

SUMMARY OF PINE STOCKING ON SAMPLE PLOTS

Plot no.	No. pine crop trees	Sum of diameters	No. weevil injuries	Percent of area occupied	Yield if fully occupied 1/	Gross yield
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
Stand totals				xx	xx	

1/ Item G from Calculation Aid

Form EWP-2, back side

RECORD PRIMARY VARIABLES HERE	17. Harvest date: (Present year) (16) ____ + ____ = ____
1. BR hazard zone High Medium Low 2. Weevil control No Yes 3. Release No Yes 4. Thinning No Yes 5. Pruning No Yes 6. Rotation age 80 100 120 7. Site index 40 50 60 70 80 8. Av. no. of crop trees per plot ____ 9. Av. DBH of crop trees ____ 10. Av. weevil injuries/foot ____ 11. No. of future workings 1 2 3 4 12. Total no. of man-days per acre ____ 13. Gross harvest volume per acre ____	18. Harvest volume saved (M board feet per acre): (B) (13) (2 no-H / 2 yes-I) (10) ____ [____ - (____ x ____)] = 19. Adjustment in quality index: (4 no-.00 / 4 yes-.05) (5 no-.00 / 5 yes-J) (10) (2 no-1.00 / 2 yes-K) .04 + ____ + ____ - (.35 x ____ x ____) = ____ 20. Unit harvest value (dollars per M board feet): (C) (19) (D) (L) (E) ____ + (____ x ____) + (____ x ____) = $____
MAKE THE FOLLOWING CALCULATIONS--Sources of data are indicated by numbers or letters in parentheses above each blank. Numbers refer to items on this sheet; letters to items on the Calculation Aid.	21. Thinning value saved (dollars): (M) (B) (20) (5 no-.00 / 5 yes-J) (D) (____ x ____) [____ - (____ x ____)] = $____
14. Normal age: (A) ____	22. Rust control cost (dollars per acre): (12) (F) ____ x ____ = $____
15. Length of control period: (6) (14) (11) ____ - ____ - 6(____ - 1) = ____	23. Profit or loss per acre (dollars): (18) (20) (21) (22) (____ x ____) + ____ - ____ = $____ per acre
16. Length of investment period: (6) (14) ____ - ____ = ____	24. Value returned per dollar spent (dollars): (18) (20) (21) (22) [(____ x ____) + ____] ÷ ____ = $____ per dollar

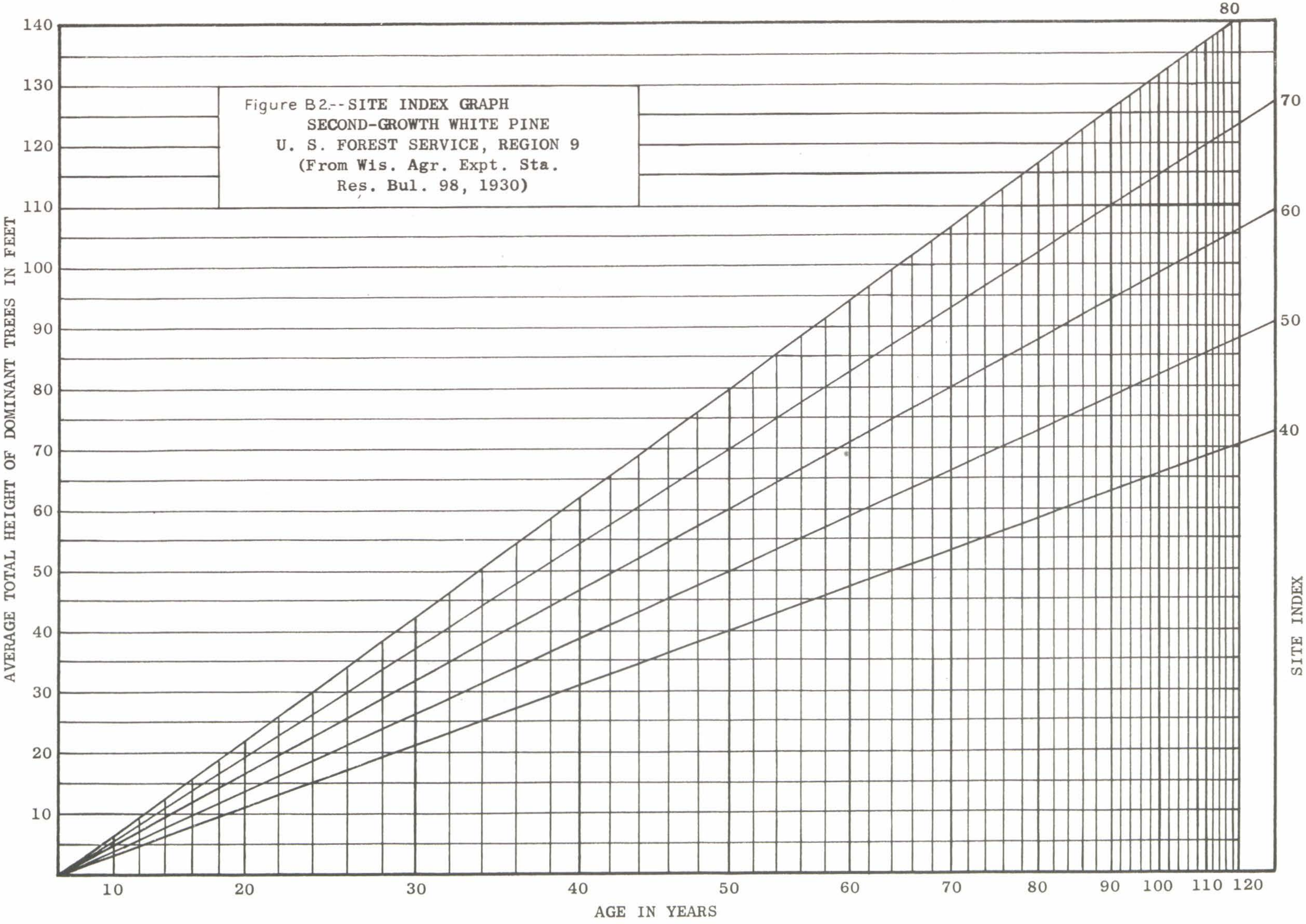


Figure B2.--SITE INDEX GRAPH
SECOND-GROWTH WHITE PINE
U. S. FOREST SERVICE, REGION 9
(From Wis. Agr. Expt. Sta.
Res. Bul. 98, 1930)
AVERAGE TOTAL HEIGHT OF DOMINANT TREES IN FEET
140
130
120
110
100
90
80
70
60
50
40
30
20
10
AGE IN YEARS
10
20
30
40
50
60
70
80
90
100
110
120
SITE INDEX
80
70
60
50
40

Figure B3-- WHITE PINE BLISTER RUST HAZARD ZONES IN THE LAKE STATES

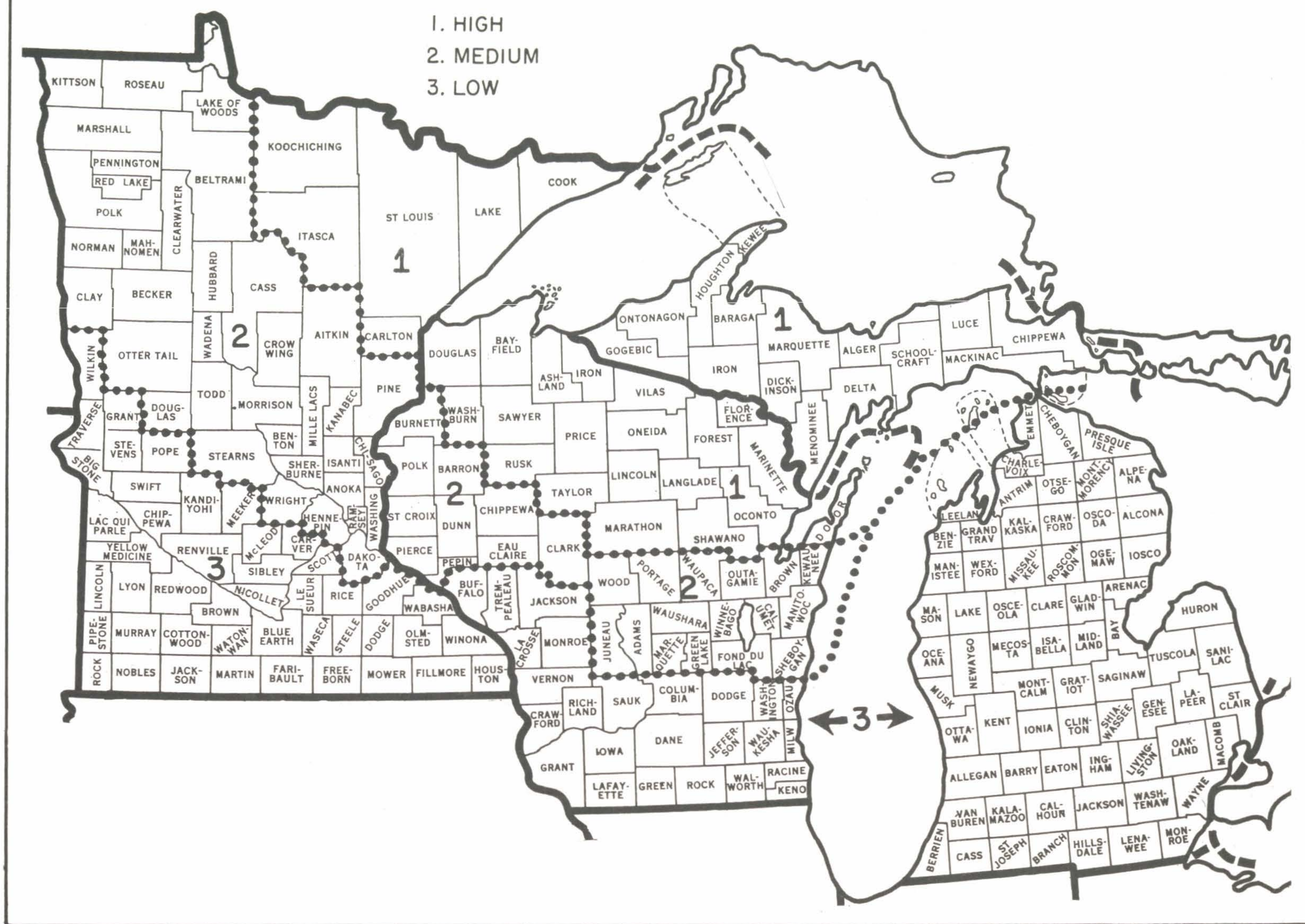


Table B1 -- SITE INDEX[1] TABLE FOR JUVENILE EASTERN WHITE PINE STANDS IN U. S. FOREST SERVICE REGION 9

Site indexes 40 through 45

Age from seed, in years

Diameter o.b. (at 1/10 of total height) in inches	2	4		6		8		10		12		14		16		18		20		22		24		26		28	
	Total height in feet	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height
0.2	0.6-0.7	0.3	1.2-1.3	0.3	1.4-1.5	0.4	1.9-2.3	0.5	2.3-2.8	0.6	3.8-4.3	0.7	5.4- 5.7	0.7	6.0- 6.4	0.8	7.4- 7.8	1.1	10.0-10.3	1.0	10.0-10.7	0.8	8.5- 9.1	0.8	9.5-10.2	0.9	10.5-11.4
.3	.7- .8	.4	1.4-1.5	.4	1.6-1.8	.5	2.1-2.6	.6	2.6-3.2	.7	4.2-4.7	.8	5.6- 6.0	.8	6.6- 6.6	.9	8.0- 8.1	1.2	10.4-10.6	1.1	10.8-11.0	.9	9.1- 9.9	.9	10.1-10.8	1.0	11.2-12.0
.4	.8- .9	.5	1.5-1.6	.5	1.9-2.1	.6	2.3-2.8	.7	2.9-3.3	.8	4.5-4.9	.9	6.1- 6.6	.9	6.9- 7.5	1.0	8.5- 8.8	1.3	10.8-11.5	1.2	11.0-11.6	1.0	10.2-10.9	1.0	10.8-11.4	1.1	11.9-12.7
		.6	1.6-1.7	.6	2.1-2.3	.7	2.7-3.0	.8	3.1-3.5	.9	4.8-5.4	1.0	6.5- 6.9	1.0	7.5- 8.2	1.1	8.8- 9.2	1.4	11.7-11.8	1.3	11.5-12.0	1.1	11.3-11.7	1.1	11.4-12.0	1.2	12.6-13.3
		.7	1.6-1.8	.7	2.1-2.4	.8	2.8-3.0	.9	3.3-3.7	1.0	5.2-5.5	1.1	6.8- 7.3	1.1	8.4- 8.6	1.2	9.6-10.1	1.5	12.1-12.4	1.4	12.0-12.4	1.2	11.9-12.2	1.2	12.0-12.6	1.3	13.3-14.0
		.8	1.7-1.9	.8	2.2-2.5	.9	2.8-3.1	1.0	3.4-3.8	1.1	5.3-5.7	1.2	7.1- 7.4	1.2	8.6- 8.9	1.3	10.2-10.5	1.6	12.4-12.7	1.5	12.5-13.4	1.3	12.5-13.0	1.3	12.7-13.8	1.4	14.0-14.7
				.9	2.4-2.6	1.0	2.9-3.3	1.1	3.5-3.9	1.2	5.5-5.8	1.3	7.2- 7.6	1.3	8.7- 9.1	1.4	10.5-10.8	1.7	12.6-13.0	1.6	13.5-13.8	1.4	13.0-13.7	1.4	13.6-14.2	1.5	14.7-15.3
				1.0	2.4-2.6	1.1	3.1-3.4	1.2	3.6-4.0	1.3	5.7-6.0	1.4	7.5- 7.9	1.4	9.0- 9.4	1.5	10.7-11.1	1.8	13.0-13.3	1.7	13.8-14.3	1.5	13.3-14.1	1.5	13.9-14.9	1.6	15.4-16.3
				1.1	2.5-2.8	1.2	3.1-3.4	1.3	3.7-4.1	1.4	5.8-6.2	1.5	7.7- 8.0	1.5	9.3- 9.7	1.6	11.0-11.4	1.9	13.2-13.6	1.8	14.0-14.3	1.6	13.6-14.4	1.6	14.6-15.5	1.7	16.1-17.2
						1.3	3.2-3.5	1.4	3.8-4.2	1.5	5.8-6.3	1.6	7.9- 8.2	1.6	9.6- 9.9	1.7	11.2-11.5	2.0	13.4-13.9	1.9	14.3-14.7	1.7	14.2-15.2	1.7	15.2-16.1	1.8	16.5-17.7
						1.4	3.3-3.7	1.5	3.9-4.3	1.6	6.0-6.4	1.7	8.1- 8.5	1.7	9.8-10.0	1.8	11.3-11.7	2.1	13.7-14.0	2.0	14.5-15.1	1.8	15.0-15.6	1.8	15.5-16.3	1.9	16.8-18.2
						1.5	3.4-3.8	1.6	4.0-4.4	1.7	6.2-6.5	1.8	8.2- 8.6	1.8	9.9-10.2	1.9	11.8-12.1	2.2	13.9-14.2	2.1	15.0-15.5	1.9	15.3-16.0	1.9	15.8-16.8	2.0	17.2-18.8
								1.7	4.1-4.5	1.8	6.3-6.6	1.9	8.3- 8.7	1.9	10.1-10.4	2.0	12.0-12.2	2.3	14.1-14.4	2.2	15.3-15.8	2.0	15.9-16.5	2.0	16.5-17.6	2.1	17.5-19.1
								1.8	4.1-4.6	1.9	6.3-6.8	2.0	8.4- 8.8	2.0	10.2-10.7	2.1	12.1-12.4	2.4	14.3-14.6	2.3	15.5-16.2	2.1	16.1-16.9	2.1	17.1-18.1	2.2	18.2-19.5
								1.9	4.2-4.7	2.0	6.5-6.9	2.1	8.6- 9.0	2.1	10.4-10.8	2.2	12.3-12.7	2.5	14.5-14.8	2.4	15.6-16.4	2.2	16.3-17.1	2.2	17.4-18.5	2.3	18.6-20.4
										2.1	6.6-7.0	2.2	8.7- 9.0	2.2	10.5-10.9	2.3	12.4-12.8	2.6	14.7-15.1	2.5	15.8-16.6	2.3	16.4-17.3	2.3	17.7-18.8	2.4	18.9-20.6
										2.2	6.7-7.2	2.3	8.8- 9.2	2.3	10.8-11.1	2.4	12.7-13.0	2.7	14.9-15.3	2.6	16.0-16.6	2.4	17.0-17.8	2.4	18.1-19.1	2.5	19.6-20.8
										2.3	6.8-7.2	2.4	8.9- 9.3	2.4	10.9-11.2	2.5	12.9-13.2	2.8	15.1-15.5	2.7	16.3-17.0	2.5	17.2-18.1	2.5	18.4-19.6	2.6	19.8-21.2
										2.4	6.8-7.3	2.5	9.1- 9.5	2.5	11.0-11.4	2.6	13.1-13.4	2.9	15.2-15.6	2.8	16.5-17.1	2.6	17.4-18.3	2.6	18.7-20.0	2.7	20.1-21.6
										2.5	6.9-7.4	2.6	9.2- 9.6	2.6	11.1-11.5	2.7	13.2-13.6	3.0	15.4-15.8	2.9	16.8-17.4	2.7	17.6-18.7	2.7	19.0-20.3	2.8	20.3-21.9
										2.6	7.0-7.5	2.7	9.2- 9.7	2.7	11.3-11.6	2.8	13.3-13.7	3.1	15.6-15.9	3.0	17.0-17.7	2.8	17.9-18.8	2.8	19.2-20.5	2.9	20.7-22.3
												2.8	9.3- 9.8	2.8	11.4-11.8	2.9	13.4-13.8	3.2	15.8-16.1	3.1	17.2-17.9	2.9	18.1-19.1	2.9	19.4-20.8	3.0	21.0-22.6
												2.9	9.5- 9.9	2.9	11.5-11.8	3.0	13.5-13.9	3.3	15.9-16.2	3.2	17.4-18.0	3.0	18.3-19.3	3.0	19.6-21.0	3.1	21.2-22.8
												3.0	9.6-10.1	3.0	11.6-12.1	3.1	13.7-14.1	3.4	16.0-16.4	3.3	17.5-18.2	3.1	18.5-19.5	3.1	19.8-21.2	3.2	21.4-23.0
												3.1	9.7-10.2	3.1	11.7-12.2	3.2	13.9-14.2	3.5	16.1-16.5	3.4	17.7-18.3	3.2	18.7-19.7	3.2	20.1-21.4	3.3	21.5-23.2
												3.2	9.8-10.3	3.2	11.9-12.4	3.3	14.0-14.4	3.6	16.2-16.7	3.5	17.8-18.4	3.3	19.0-20.0	3.3	20.3-21.6	3.4	21.7-23.4
														3.3	12.0-12.4	3.4	14.1-14.5	3.7	16.4-16.8	3.6	17.9-18.6	3.4	19.3-20.2	3.4	20.5-21.9	3.5	22.1-23.8
														3.4	12.1-12.5	3.5	14.2-14.6	3.8	16.5-16.9	3.7	18.0-18.8	3.5	19.5-20.4	3.5	20.7-22.1	3.6	22.4-24.1
														3.5	12.2-12.6	3.6	14.3-14.8	3.9	16.7-17.1	3.8	18.2-18.9	3.6	19.7-20.6	3.6	20.9-22.3	3.7	22.6-24.3
														3.6	12.3-12.8	3.7	14.4-14.9	4.0	16.8-17.3	3.9	18.3-19.0	3.7	19.8-20.7	3.7	21.2-22.6	3.8	22.8-24.5
														3.7	12.4-12.9	3.8	14.5-15.0	4.1	16.9-17.3	4.0	18.4-19.2	3.8	19.9-20.8	3.8	21.5-22.9	3.9	22.9-24.7
														3.8	12.5-13.0	3.9	14.6-15.1	4.2	17.0-17.4	4.1	18.5-19.3	3.9	20.0-21.0	3.9	21.9-23.2	4.0	23.1-24.9
														3.9	12.6-13.1	4.0	14.8-15.2	4.3	17.1-17.6	4.2	18.7-19.4	4.0	20.1-21.1	4.0	22.2-23.4	4.1	23.5-25.2
																4.1	15.0-15.4	4.4	17.2-17.7	4.3	18.8-19.6	4.1	20.2-21.2	4.1	22.3-23.5	4.2	23.8-25.4
																4.2	15.1-15.5	4.5	17.3-17.8	4.4	18.9-19.7	4.2	20.3-21.3	4.2	22.4-23.6	4.3	24.2-25.7
																4.3	15.2-15.6	4.6	17.5-18.0	4.5	19.0-19.8	4.3	20.4-21.4	4.3	22.4-23.7	4.4	24.5-25.9
																4.4	15.3-15.7	4.7	17.7-18.1	4.6	19.2-19.9	4.4	20.6-21.6	4.4	22.5-23.8	4.5	24.6-26.1
																4.5	15.4-15.8	4.8	17.8-18.2	4.7	19.3-20.0	4.5	20.8-21.8	4.5	22.6-23.9	4.6	24.6-26.1
																		4.9	17.9-18.3	4.8	19.4-20.1	4.6	20.9-21.9	4.6	22.7-24.1	4.7	24.7-26.3
																		5.0	18.0-18.4	4.9	19.5-20.3	4.7	21.0-22.1	4.7	22.7-24.2	4.8	24.8-26.4
																		5.1	18.1-18.5	5.0	19.6-20.4	4.8	21.1-22.3	4.8	22.8-24.3	4.9	24.9-26.5
																		5.2	18.2-18.6	5.1	19.7-20.6	4.9	21.2-22.4	4.9	22.9-24.5	5.0	24.9-26.6
																				5.2	19.8-20.7	5.0	21.3-22.6	5.0	23.0-24.6	5.1	25.0-26.7
																				5.3	19.9-20.8	5.1	21.4-22.6	5.1	23.1-24.8	5.2	25.1-26.8
																				5.4	20.0-20.9	5.2	21.4-22.7	5.2	23.3-24.9	5.3	25.1-26.9
																				5.5	20.2-21.0	5.3	21.5-22.8	5.3	23.4-25.1	5.4	25.2-27.0
																				5.6	20.3-21.1	5.4	21.7-22.9	5.4	23.5-25.2	5.5	25.3-27.2
																				5.7	20.4-21.2	5.5	21.9-23.0	5.5	23.6-25.4	5.6	25.5-27.4
																				5.8	20.5-21.3	5.6	22.0-23.1	5.6	23.7-25.5	5.7	25.6-27.6
																				5.9	20.6-21.4	5.7	22.1-23.2	5.7	23.8-25.6	5.8	25.7-27.7
																				6.0	20.7-21.6	5.8	22.3-23.4	5.8	23.9-25.7	5.9	25.9-27.9
																				6.1	20.8-21.7	5.9	22.4-23.6	5.9	24.0-25.7	6.0	26.0-28.1
																				6.2	20.9-21.8	6.0	22.5-23.7	6.0	24.1-25.8	6.1	26.1-28.2

1/ Site index is the average total height of dominant trees at age 50.

RS-LS
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SITE INDEX TABLE FOR JUVENILE EASTERN WHITE PINE STANDS IN U. S. FOREST SERVICE REGION 9

Site indexes 46 through 55

Age from seed, in years

2		4		6		8		10		12		14		16		18		20		22		24		26		28	
Diameter o.b. (at 1/10 of total height) in inches	Total height in feet	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height
0.3	0.9-1.0	0.4	1.6-1.8	0.5	2.2-2.5	0.7	3.1-3.5	0.7	3.4-3.8	1.1	5.8-6.3	1.2	7.5- 8.0	1.6	10.0-10.5	1.7	11.6-12.0	2.1	14.1-14.6	1.8	14.4-15.2	1.6	14.5-15.5	1.6	15.6-16.3	1.8	17.8-18.9
.4	1.0-1.1	.5	1.7-1.9	.6	2.4-2.7	.8	3.1-3.6	.8	3.6-4.1	1.2	5.9-6.5	1.3	7.7- 8.3	1.7	10.1-10.6	1.8	11.8-12.3	2.2	14.3-14.8	1.9	14.8-15.5	1.7	15.3-15.9	1.7	16.2-17.3	1.9	18.3-19.9
		.6	1.8-2.0	.7	2.5-2.9	.9	3.2-3.8	.9	3.8-4.4	1.3	6.1-6.7	1.4	8.0- 8.5	1.8	10.3-11.0	1.9	12.2-12.7	2.3	14.5-15.0	2.0	15.2-15.9	1.8	15.7-16.4	1.8	16.4-17.6	2.0	18.9-20.5
		.7	1.9-2.2	.8	2.6-3.0	1.0	3.4-3.9	1.0	3.9-4.6	1.4	6.3-7.0	1.5	8.1- 8.7	1.9	10.5-11.2	2.0	12.3-13.0	2.4	14.7-15.3	2.1	15.6-16.3	1.9	16.1-16.8	1.9	16.9-18.1	2.1	19.2-21.0
		.8	2.0-2.3	.9	2.7-3.1	1.1	3.5-4.1	1.1	4.0-4.7	1.5	6.4-7.2	1.6	8.3- 8.9	2.0	10.8-11.4	2.1	12.5-13.1	2.5	14.9-15.6	2.2	15.9-16.6	2.0	16.6-17.5	2.0	17.7-19.1	2.2	19.6-21.4
				1.0	2.7-3.2	1.2	3.5-4.2	1.2	4.1-4.9	1.6	6.5-7.2	1.7	8.6- 9.2	2.1	10.9-11.5	2.2	12.8-13.4	2.6	15.2-15.8	2.3	16.3-17.1	2.1	17.0-18.0	2.1	18.2-19.5	2.3	20.5-21.8
				1.1	2.9-3.4	1.3	3.6-4.3	1.3	4.2-5.0	1.7	6.6-7.4	1.8	8.7- 9.3	2.2	11.0-11.8	2.3	12.9-13.7	2.7	15.4-16.0	2.4	16.5-17.3	2.2	17.2-18.4	2.2	18.6-20.1	2.4	20.7-22.2
				1.2	2.9-3.5	1.4	3.8-4.4	1.4	4.3-5.1	1.8	6.7-7.6	1.9	8.8- 9.5	2.3	11.2-11.9	2.4	13.1-13.7	2.8	15.6-16.2	2.5	16.7-17.6	2.3	17.4-18.8	2.3	18.9-20.5	2.5	20.9-22.8
				1.3	2.9-3.5	1.5	3.9-4.6	1.5	4.4-5.2	1.9	6.9-7.7	2.0	8.9- 9.7	2.4	11.3-12.1	2.5	13.3-13.9	2.9	15.7-16.4	2.6	16.7-17.9	2.4	17.9-19.1	2.4	19.2-21.1	2.6	21.3-23.3
						1.6	3.9-4.6	1.6	4.5-5.4	2.0	7.0-7.9	2.1	9.1- 9.8	2.5	11.5-12.3	2.6	13.5-14.2	3.0	15.9-16.5	2.7	17.1-18.1	2.5	18.2-19.6	2.5	19.7-21.4	2.7	21.7-23.7
						1.7	4.0-4.7	1.7	4.6-5.5	2.1	7.1-8.0	2.2	9.1-10.0	2.6	11.6-12.4	2.7	13.7-14.4	3.1	16.0-16.8	2.8	17.2-18.4	2.6	18.4-19.8	2.6	20.1-21.8	2.8	22.0-24.2
								1.8	4.7-5.6	2.2	7.3-8.2	2.3	9.3-10.1	2.7	11.7-12.5	2.8	13.8-14.5	3.2	16.2-16.9	2.9	17.5-18.7	2.7	18.8-20.1	2.7	20.4-22.1	2.9	22.4-24.6
								1.9	4.8-5.7	2.3	7.3-8.3	2.4	9.4-10.2	2.8	11.9-12.7	2.9	13.9-14.7	3.3	16.3-17.1	3.0	17.8-18.9	2.8	18.9-20.4	2.8	20.6-22.4	3.0	22.7-25.0
								2.0	4.9-5.8	2.4	7.4-8.3	2.5	9.6-10.4	2.9	11.9-12.9	3.0	14.0-14.8	3.4	16.5-17.3	3.1	18.0-19.1	2.9	19.2-20.8	2.9	20.9-22.8	3.1	22.9-25.3
								2.1	5.0-5.9	2.5	7.5-8.4	2.6	9.7-10.6	3.0	12.2-13.1	3.1	14.2-14.9	3.5	16.6-17.4	3.2	18.1-19.3	3.0	19.4-21.1	3.0	21.1-23.1	3.2	23.1-25.6
										2.6	7.6-8.6	2.7	9.8-10.8	3.1	12.3-13.2	3.2	14.3-15.1	3.6	16.8-17.5	3.3	18.3-19.5	3.1	19.6-21.3	3.1	21.3-23.5	3.3	23.3-25.8
										2.7	7.7-8.7	2.8	9.9-10.9	3.2	12.5-13.3	3.3	14.5-15.2	3.7	16.9-17.7	3.4	18.4-19.7	3.2	19.8-21.5	3.2	21.5-23.7	3.4	23.5-26.0
										2.8	7.8-8.7	2.9	10.0-11.0	3.3	12.5-13.4	3.4	14.6-15.4	3.8	17.0-17.9	3.5	18.5-20.0	3.3	20.1-21.8	3.3	21.7-23.9	3.5	23.9-26.5
												3.0	10.2-11.1	3.4	12.6-13.5	3.5	14.7-15.7	3.9	17.2-18.0	3.6	18.7-20.1	3.4	20.3-21.9	3.4	22.0-24.2	3.6	24.2-26.9
												3.1	10.3-11.1	3.5	12.7-13.6	3.6	14.9-15.8	4.0	17.4-18.2	3.7	18.9-20.2	3.5	20.5-22.1	3.5	22.2-24.5	3.7	24.4-27.2
												3.2	10.4-11.3	3.6	12.9-13.7	3.7	15.0-15.9	4.1	17.4-18.3	3.8	19.0-20.4	3.6	20.7-22.3	3.6	22.4-24.7	3.8	24.6-27.4
												3.3	10.5-11.4	3.7	13.0-13.9	3.8	15.1-16.0	4.2	17.5-18.5	3.9	19.1-20.5	3.7	20.8-22.6	3.7	22.7-25.0	3.9	24.8-27.6
												3.4	10.6-11.6	3.8	13.1-14.0	3.9	15.2-16.2	4.3	17.7-18.6	4.0	19.3-20.7	3.8	20.9-22.8	3.8	23.0-25.2	4.0	25.0-27.9
												3.5	10.7-11.6	3.9	13.2-14.1	4.0	15.3-16.3	4.4	17.8-18.7	4.1	19.4-20.9	3.9	21.1-23.0	3.9	23.3-25.4	4.1	25.3-28.1
														4.0	13.3-14.2	4.1	15.5-16.4	4.5	17.9-18.9	4.2	19.5-21.1	4.0	21.2-23.1	4.0	23.5-25.6	4.2	25.5-28.3
														4.1	13.4-14.4	4.2	15.6-16.5	4.6	18.1-19.0	4.3	19.7-21.2	4.1	21.3-23.3	4.1	23.6-25.8	4.3	25.8-28.5
																4.3	15.7-16.6	4.7	18.2-19.1	4.4	19.8-21.4	4.2	21.4-23.5	4.2	23.7-26.0	4.4	26.0-28.7
																4.4	15.8-16.7	4.8	18.3-19.2	4.5	19.9-21.5	4.3	21.5-23.7	4.3	23.8-26.3	4.5	26.2-28.9
																4.5	15.9-16.8	4.9	18.4-19.3	4.6	20.0-21.6	4.4	21.7-23.8	4.4	23.9-26.4	4.6	26.2-29.1
																4.6	16.0-17.0	5.0	18.5-19.4	4.7	20.1-21.8	4.5	21.9-24.0	4.5	24.0-26.5	4.7	26.4-29.2
																4.7	16.1-17.1	5.1	18.6-19.6	4.8	20.2-21.9	4.6	22.0-24.1	4.6	24.2-26.7	4.8	26.5-29.4
																4.8	16.3-17.2	5.2	18.7-19.7	4.9	20.4-22.0	4.7	22.2-24.3	4.7	24.3-26.9	4.9	26.6-29.6
																		5.3	18.8-19.8	5.0	20.5-22.1	4.8	22.4-24.5	4.8	24.4-27.1	5.0	26.7-29.8
																		5.4	18.9-19.9	5.1	20.7-22.3	4.9	22.5-24.7	4.9	24.6-27.3	5.1	26.8-30.0
																		5.5	19.0-20.0	5.2	20.8-22.4	5.0	22.7-24.8	5.0	24.7-27.4	5.2	26.9-30.2
																				5.3	20.9-22.5	5.1	22.7-25.0	5.1	24.9-27.6	5.3	27.0-30.3
																				5.4	21.0-22.6	5.2	22.8-25.1	5.2	25.0-27.8	5.4	27.1-30.5
																				5.5	21.1-22.7	5.3	22.9-25.3	5.3	25.2-28.0	5.5	27.3-30.7
																				5.6	21.2-22.8	5.4	23.0-25.4	5.4	25.3-28.1	5.6	27.5-30.9
																				5.7	21.3-22.9	5.5	23.1-25.5	5.5	25.5-28.3	5.7	27.7-31.0
																				5.8	21.4-23.0	5.6	23.2-25.6	5.6	25.6-28.5	5.8	27.8-31.2
																				5.9	21.5-23.2	5.7	23.3-25.7	5.7	25.7-28.6	5.9	28.0-31.4
																				6.0	21.7-23.3	5.8	23.5-25.9	5.8	25.8-28.7	6.0	28.2-31.6
																				6.1	21.8-23.4	5.9	23.7-26.0	5.9	25.8-28.8	6.1	28.3-31.8
																				6.2	21.9-23.5	6.0	23.8-26.1	6.0	25.9-28.9	6.2	28.5-32.0
																				6.3	22.0-23.6	6.1	23.9-26.2	6.1	26.0-29.0	6.3	28.6-32.1
																				6.4	22.1-23.7	6.2	24.0-26.4	6.2	26.1-29.1	6.4	28.6-32.2
																				6.5	22.2-23.9	6.3	24.1-26.5	6.3	26.2-29.2	6.5	28.7-32.3
																				6.6	22.3-24.0	6.4	24.2-26.6	6.4	26.2-29.3	6.6	28.7-32.4
																						6.5	24.2-26.7	6.5	26.3-29.4	6.7	28.8-32.5
																						6.6	24.4-26.8	6.6	26.4-29.5	6.8	28.8-32.6
																						6.7	24.5-26.9	6.7	26.5-29.6	6.9	28.9-32.8
																						6.8	24.6-27.0	6.8	26.6-29.8	7.0	29.0-32.8

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SITE INDEX TABLE FOR JUVENILE EASTERN WHITE PINE STANDS IN U. S. FOREST SERVICE REGION 9

Site indexes 56 through 65

Age from seed, in years

2		4		6		8		10		12		14		16		18		20		22		24		26		28	
Diameter o.b. (at 1/10 of total height) in inches	Total height in feet	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height
0.3	1.1-1.2	0.5	2.0-2.3	0.5	2.6-2.9	0.7	3.6-4.0	0.7	3.9-4.4	1.1	6.4- 7.3	1.2	8.1- 9.2	1.6	10.6-12.0	1.7	12.1-13.8	2.1	14.7-16.8	1.8	15.3-16.9	1.6	15.6-17.1	1.6	16.4-18.1	1.8	19.0-20.5
.4	1.2-1.3	.6	2.1-2.5	.6	2.8-3.2	.8	3.7-4.3	.8	4.2-4.8	1.2	6.6- 7.6	1.3	8.4- 9.5	1.7	10.7-12.5	1.8	12.4-14.0	2.2	14.9-17.1	1.9	15.6-17.6	1.7	16.0-17.6	1.7	17.4-18.9	1.9	20.0-21.6
.5	1.3-1.4	.7	2.3-2.6	.7	3.0-3.4	.9	3.9-4.5	.9	4.5-5.2	1.3	6.8- 7.8	1.4	8.6- 9.8	1.8	11.1-12.7	1.9	12.8-14.6	2.3	15.1-17.5	2.0	16.0-18.3	1.8	16.5-18.3	1.8	17.7-19.4	2.0	20.6-22.2
		.8	2.4-2.8	.8	3.1-3.6	1.0	4.0-4.8	1.0	4.7-5.3	1.4	7.1- 8.2	1.5	8.8-10.1	1.9	11.3-13.2	2.0	13.1-15.1	2.4	15.4-17.9	2.1	16.4-18.5	1.9	16.9-19.0	1.9	18.2-20.4	2.1	21.1-23.1
		.9	2.4-2.8	.9	3.2-3.8	1.1	4.2-4.9	1.1	4.8-5.6	1.5	7.3- 8.4	1.6	9.0-10.4	2.0	11.5-13.4	2.1	13.2-15.3	2.5	15.7-18.3	2.2	16.7-18.8	2.0	17.6-19.5	2.0	19.2-21.2	2.2	21.5-23.7
		1.0	2.6-3.0	1.0	3.3-3.9	1.2	4.3-5.0	1.2	5.0-5.8	1.6	7.3- 8.6	1.7	9.3-10.7	2.1	11.6-13.7	2.2	13.5-15.8	2.6	15.9-18.6	2.3	17.2-19.2	2.1	18.1-20.3	2.1	19.6-21.7	2.3	21.9-24.3
		1.1	2.6-3.1	1.1	3.5-4.0	1.3	4.4-5.1	1.3	5.1-6.0	1.7	7.5- 8.8	1.8	9.4-11.0	2.2	11.9-13.9	2.3	13.8-16.0	2.7	16.1-18.9	2.4	17.4-19.8	2.2	18.5-20.8	2.2	20.2-22.2	2.4	22.3-24.8
				1.2	3.6-4.1	1.4	4.5-5.3	1.4	5.2-6.1	1.8	7.7- 9.0	1.9	9.6-11.2	2.3	12.0-14.1	2.4	13.8-16.2	2.8	16.3-19.1	2.5	17.7-20.2	2.3	18.9-21.3	2.3	20.6-22.7	2.5	22.9-25.4
				1.3	3.6-4.2	1.5	4.7-5.4	1.5	5.3-6.3	1.9	7.8- 9.1	2.0	9.8-11.5	2.4	12.2-14.3	2.5	14.0-16.4	2.9	16.5-19.3	2.6	18.0-20.7	2.4	19.2-21.7	2.4	21.2-23.2	2.6	23.4-25.8
				1.4	3.7-4.3	1.6	4.7-5.4	1.6	5.5-6.4	2.0	8.0- 9.3	2.1	9.9-11.6	2.5	12.4-14.6	2.6	14.3-16.8	3.0	16.6-19.5	2.7	18.2-21.0	2.5	19.7-22.2	2.5	21.5-23.8	2.7	23.8-26.2
				1.5	3.8-4.4	1.7	4.8-5.5	1.7	5.6-6.5	2.1	8.1- 9.5	2.2	10.1-11.8	2.6	12.5-14.7	2.7	14.5-17.0	3.1	16.9-19.9	2.8	18.5-21.4	2.6	19.9-22.5	2.6	21.9-24.2	2.8	24.3-26.9
				1.6	3.8-4.5	1.8	4.8-5.8	1.8	5.7-6.6	2.2	8.3- 9.6	2.3	10.2-12.0	2.7	12.6-14.8	2.8	14.6-17.2	3.2	17.0-20.0	2.9	18.8-21.6	2.7	20.2-22.8	2.7	22.2-24.6	2.9	24.7-27.4
						1.9	5.0-5.8	1.9	5.8-6.7	2.3	8.4- 9.7	2.4	10.3-12.1	2.8	12.8-15.0	2.9	14.8-17.4	3.3	17.2-20.2	3.0	19.0-22.0	2.8	20.5-23.3	2.8	22.5-25.0	3.0	25.1-28.0
						2.0	5.0-5.9	2.0	5.9-6.8	2.4	8.4- 9.8	2.5	10.5-12.3	2.9	13.0-15.1	3.0	14.9-17.6	3.4	17.4-20.5	3.1	19.2-22.2	2.9	20.9-23.8	2.9	22.9-25.6	3.1	25.4-28.3
						2.1	5.0-6.0	2.1	6.0-6.9	2.5	8.5- 9.9	2.6	10.7-12.5	3.0	13.2-15.5	3.1	15.0-17.7	3.5	17.5-20.6	3.2	19.4-22.5	3.0	21.2-24.2	3.0	23.2-26.0	3.2	25.7-28.6
						2.2	5.1-6.1	2.2	6.0-7.1	2.6	8.7-10.1	2.7	10.9-12.7	3.1	13.3-15.6	3.2	15.2-17.9	3.6	17.6-20.7	3.3	19.6-22.7	3.1	21.4-24.6	3.1	23.6-26.3	3.3	25.9-29.1
								2.3	6.1-7.2	2.7	8.8-10.2	2.8	11.0-12.8	3.2	13.4-15.8	3.3	15.3-18.0	3.7	17.8-20.9	3.4	19.8-23.0	3.2	21.6-24.8	3.2	23.8-26.6	3.4	26.1-29.3
								2.4	6.1-7.3	2.8	8.8-10.2	2.9	11.1-13.0	3.3	13.5-15.8	3.4	15.5-18.2	3.8	18.0-21.1	3.5	20.1-23.3	3.3	21.9-25.0	3.3	24.0-27.0	3.5	26.6-29.7
								2.5	6.2-7.4	2.9	8.9-10.5	3.0	11.2-13.1	3.4	13.6-15.9	3.5	15.8-18.5	3.9	18.1-21.3	3.6	20.2-23.5	3.4	22.0-25.3	3.4	24.3-27.4	3.6	27.0-30.2
								2.6	6.3-7.5	3.0	8.9-10.6	3.1	11.2-13.1	3.5	13.7-16.1	3.6	15.9-18.6	4.0	18.3-21.5	3.7	20.3-23.6	3.5	22.2-25.6	3.5	24.6-27.9	3.7	27.3-30.6
								2.7	6.4-7.6	3.1	8.9-10.7	3.2	11.4-13.3	3.6	13.8-16.3	3.7	16.0-18.7	4.1	18.4-21.7	3.8	20.5-23.8	3.6	22.4-25.9	3.6	24.8-28.2	3.8	27.5-31.0
										3.2	9.0-10.7	3.3	11.5-13.4	3.7	14.0-16.4	3.8	16.1-19.0	4.2	18.6-21.8	3.9	20.6-24.1	3.7	22.7-26.2	3.7	25.1-28.5	3.9	27.7-31.3
										3.3	9.0-10.9	3.4	11.7-13.5	3.8	14.1-16.5	3.9	16.3-19.1	4.3	18.7-22.0	4.0	20.8-24.2	3.8	22.9-26.4	3.8	25.3-28.7	4.0	28.0-31.6
										3.4	9.0-10.9	3.5	11.7-13.7	3.9	14.2-16.6	4.0	16.4-19.2	4.4	18.8-22.2	4.1	21.0-24.4	3.9	23.1-26.6	3.9	25.5-29.0	4.1	28.2-32.0
										3.5	9.1-11.1	3.6	11.8-13.8	4.0	14.3-16.8	4.1	16.5-19.4	4.5	19.0-22.3	4.2	21.2-24.6	4.0	23.2-26.8	4.0	25.7-29.2	4.2	28.4-32.2
										3.6	9.1-11.2	3.7	11.9-13.9	4.1	14.5-17.0	4.2	16.6-19.5	4.6	19.1-22.5	4.3	21.3-24.7	4.1	23.4-27.0	4.1	25.9-29.5	4.3	28.6-32.4
												3.8	12.0-14.0	4.2	14.6-17.1	4.3	16.7-19.6	4.7	19.2-22.6	4.4	21.5-25.0	4.2	23.6-27.3	4.2	26.1-30.0	4.4	28.8-32.6
												3.9	12.1-14.1	4.3	14.7-17.2	4.4	16.8-19.7	4.8	19.3-22.7	4.5	21.6-25.1	4.3	23.8-27.5	4.3	26.4-30.1	4.5	29.0-32.9
												4.0	12.2-14.2	4.4	14.8-17.3	4.5	16.9-19.9	4.9	19.4-22.8	4.6	21.7-25.3	4.4	23.9-27.7	4.4	26.5-30.4	4.6	29.2-33.2
												4.1	12.4-14.4	4.5	14.9-17.4	4.6	17.1-20.1	5.0	19.5-23.0	4.7	21.9-25.5	4.5	24.1-27.9	4.5	26.6-30.6	4.7	29.3-33.4
												4.2	12.5-14.6	4.6	15.0-17.5	4.7	17.2-20.2	5.1	19.7-23.1	4.8	22.0-25.6	4.6	24.2-28.1	4.6	26.8-30.8	4.8	29.5-33.6
												4.3	12.6-14.7	4.7	15.1-17.6	4.8	17.3-20.3	5.2	19.8-23.2	4.9	22.1-25.7	4.7	24.4-28.2	4.7	27.0-30.9	4.9	29.7-33.9
												4.4	12.7-14.8	4.8	15.2-17.7	4.9	17.3-20.4	5.3	19.9-23.4	5.0	22.2-25.9	4.8	24.6-28.4	4.8	27.2-31.1	5.0	29.9-34.2
												4.5	12.8-14.9	4.9	15.3-17.9	5.0	17.4-20.5	5.4	20.0-23.6	5.1	22.4-26.0	4.9	24.8-28.5	4.9	27.4-31.3	5.1	30.1-34.4
														5.0	15.4-17.9	5.1	17.5-20.6	5.5	20.1-23.7	5.2	22.5-26.3	5.0	24.9-28.6	5.0	27.5-31.5	5.2	30.3-34.6
														5.1	15.5-18.1	5.2	17.6-20.8	5.6	20.2-23.8	5.3	22.6-26.4	5.1	25.1-28.9	5.1	27.7-31.7	5.3	30.4-34.8
														5.2	15.6-18.2	5.3	17.7-20.9	5.7	20.3-23.9	5.4	22.7-26.6	5.2	25.2-29.1	5.2	27.9-31.8	5.4	30.6-35.0
														5.3	15.7-18.3	5.4	17.9-21.0	5.8	20.4-24.1	5.5	22.8-26.7	5.3	25.4-29.3	5.3	28.1-32.0	5.5	30.8-35.2
														5.4	15.8-18.4	5.5	18.0-21.1	5.9	20.5-24.2	5.6	22.9-26.8	5.4	25.5-29.5	5.4	28.2-32.2	5.6	31.0-35.4
																5.6	18.1-21.3	6.0	20.6-24.3	5.7	23.0-26.9	5.5	25.6-29.6	5.5	28.4-32.5	5.7	31.1-35.5
																5.7	18.2-21.4	6.1	20.7-24.4	5.8	23.1-27.1	5.6	25.7-29.8	5.6	28.6-32.6	5.8	31.3-35.7
																5.8	18.3-21.5	6.2	20.8-24.5	5.9	23.3-27.2	5.7	25.8-30.0	5.7	28.7-32.8	5.9	31.5-35.8
																5.9	18.5-21.6	6.3	20.9-24.6	6.0	23.4-27.4	5.8	26.0-30.1	5.8	28.8-32.9	6.0	31.7-36.0
																6.0	18.6-21.8	6.4	21.0-24.8	6.1	23.5-27.5	5.9	26.1-30.2	5.9	28.9-33.0	6.1	31.9-36.2
																6.1	18.7-21.9	6.5	21.2-24.9	6.2	23.6-27.6	6.0	26.2-30.4	6.0	29.0-33.2	6.2	32.1-36.4
																6.2	18.7-21.9	6.6	21.3-25.1	6.3	23.7-27.8	6.1	26.3-30.5	6.1	29.1-33.3	6.3	32.2-36.6
																6.3	18.8-22.0	6.7	21.4-25.2	6.4	23.8-27.9	6.2	26.5-30.7	6.2	29.2-33.5	6.4	32.3-36.7
																		6.8	21.5-25.3	6.5	24.0-28.1	6.3	26.6-30.8	6.3	29.3-33.7	6.5	32.4-36.9
																		6.9	21.6-25.4	6.6	24.1-28.2	6.4	26.7-30.9	6.4	29.4-33.9	6.6	32.5-37.0
																		7.0	21.7-25.5	6.7	24.1-28.2	6.5	26.8-31.0	6.5	29.5-34.0	6.7	32.6-37.2
																		7.1	21.8-25.6	6.8	24.2-28.4	6.6	26.9-31.1	6.6	29.6-34.1	6.8	32.7-37.4
																		7.2	21.9-25.7	6.9	24.3-28.5	6.7	27.0-31.2	6.7	29.7-34.3	6.9	32.9-37.6
																				7.0	24.4-28.6	6.8	27.1-31.3	6.8	29.9-34.4	7.0	32.9-37.9

RS-LS
RESEARCH PROGRAM
General
Eastern white pine study

SITE INDEX TABLE FOR JUVENILE EASTERN WHITE PINE STANDS IN U. S. FOREST SERVICE REGION 9

Site indexes 66 through 75

Age from seed, in years

Diameter o.b. (at 1/10 of total height) in inches	2	4		6		8		10		12		14		16		18		20		22		24		26		28	
	Total height in feet	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height
0.4	1.4-1.5	0.5	2.4-2.7	0.6	3.3-3.4	0.8	4.4-4.8	0.6	3.9-4.5	0.6	5.1- 6.2	0.8	7.1- 8.4	0.9	8.4-10.5	1.1	10.5-12.8	1.2	12.1-14.9	1.3	14.0-17.0	1.5	16.4-19.3	1.6	18.2-21.3	1.8	20.6-23.7
.5	1.5-1.6	.6	2.6-3.0	.7	3.5-3.8	.9	4.6-5.0	.7	4.5-5.0	.7	5.7- 6.5	.9	7.6- 9.2	1.0	8.9-11.0	1.2	11.2-14.0	1.3	12.7-15.5	1.4	14.6-17.3	1.6	17.2-20.0	1.7	19.0-21.8	1.9	21.7-24.5
		.7	2.7-3.0	.8	3.7-4.2	1.0	4.9-5.3	.8	4.9-5.4	.8	6.0- 7.0	1.0	8.2- 9.7	1.1	9.7-11.8	1.3	12.1-14.5	1.4	13.2-16.4	1.5	15.0-18.1	1.7	17.7-20.8	1.8	19.5-22.6	2.0	22.3-25.4
		.8	2.9-3.2	.9	3.9-4.3	1.1	5.0-5.5	.9	5.3-5.8	.9	6.6- 7.7	1.1	8.7-10.4	1.2	10.4-12.8	1.4	12.4-15.5	1.5	14.1-17.0	1.6	15.8-18.8	1.8	18.4-21.4	1.9	20.5-23.6	2.1	23.2-26.3
		.9	2.9-3.3	1.0	4.0-4.4	1.2	5.1-5.7	1.0	5.4-6.0	1.0	7.1- 8.2	1.2	9.3-11.0	1.3	10.9-13.2	1.5	12.8-15.9	1.6	14.4-18.1	1.7	16.6-19.5	1.9	19.1-22.0	2.0	21.3-24.4	2.2	23.8-26.9
		1.0	3.1-3.4	1.1	4.1-4.6	1.3	5.2-5.9	1.1	5.7-6.3	1.1	7.4- 8.6	1.3	9.6-11.5	1.4	11.3-13.7	1.6	13.4-16.6	1.7	15.1-18.6	1.8	17.0-20.7	2.0	19.6-23.4	2.1	21.8-25.2	2.3	24.4-27.8
		1.1	3.2-3.5	1.2	4.2-4.7	1.4	5.4-6.0	1.2	5.9-6.6	1.2	7.7- 9.0	1.4	9.9-12.1	1.5	11.7-14.3	1.7	13.9-17.0	1.8	15.6-19.4	1.9	17.7-21.3	2.1	20.4-24.1	2.2	22.3-25.8	2.4	24.9-28.4
				1.3	4.3-4.9	1.5	5.5-6.1	1.3	6.1-6.8	1.3	7.9- 9.4	1.5	10.2-12.4	1.6	12.1-14.8	1.8	14.1-17.7	1.9	16.1-19.9	2.0	18.4-22.0	2.2	20.9-24.8	2.3	22.8-26.3	2.5	25.5-28.9
				1.4	4.4-5.0	1.6	5.5-6.3	1.4	6.2-7.0	1.4	8.3- 9.6	1.6	10.5-12.8	1.7	12.6-15.3	1.9	14.7-18.3	2.0	16.4-20.7	2.1	18.6-22.6	2.3	21.4-25.3	2.4	23.3-27.1	2.6	25.9-29.8
				1.5	4.5-5.0	1.7	5.6-6.4	1.5	6.4-7.1	1.5	8.5-10.1	1.7	10.8-13.1	1.8	12.8-16.0	2.0	15.2-18.8	2.1	16.9-21.2	2.2	18.9-23.1	2.4	21.8-25.7	2.5	23.9-27.6	2.7	26.3-30.4
				1.6	4.6-5.2	1.8	5.9-6.6	1.6	6.5-7.3	1.6	8.7-10.3	1.8	11.1-13.5	1.9	13.3-16.2	2.1	15.4-19.4	2.2	17.2-21.8	2.3	19.3-23.7	2.5	22.3-26.5	2.6	24.3-28.4	2.8	27.0-31.0
						1.9	5.9-6.6	1.7	6.6-7.4	1.7	8.9-10.5	1.9	11.3-13.9	2.0	13.5-16.9	2.2	15.9-19.7	2.3	17.6-22.2	2.4	19.9-24.3	2.6	22.6-27.0	2.7	24.7-28.9	2.9	27.5-31.6
						2.0	6.0-6.8	1.8	6.7-7.6	1.8	9.1-10.7	2.0	11.6-14.1	2.1	13.8-17.1	2.3	16.1-20.2	2.4	18.0-22.7	2.5	20.3-24.9	2.7	22.9-27.4	2.8	25.1-29.5	3.0	28.1-32.5
						2.1	6.1-6.9	1.9	6.8-7.7	1.9	9.2-10.9	2.1	11.7-14.3	2.2	14.0-17.3	2.4	16.3-20.5	2.5	18.4-23.1	2.6	20.8-25.4	2.8	23.4-28.1	2.9	25.7-30.0	3.1	28.4-32.8
						2.2	6.2-7.0	2.0	6.9-7.9	2.0	9.4-11.2	2.2	11.9-14.5	2.3	14.2-17.5	2.5	16.5-20.7	2.6	18.7-23.6	2.7	21.1-25.8	2.9	23.9-28.7	3.0	26.1-30.5	3.2	28.7-33.1
								2.1	7.0-8.0	2.1	9.6-11.4	2.3	12.1-14.8	2.4	14.4-17.8	2.6	16.9-21.1	2.7	19.0-24.0	2.8	21.5-26.3	3.0	24.3-29.0	3.1	26.4-31.0	3.3	29.2-33.6
								2.2	7.2-8.1	2.2	9.7-11.5	2.4	12.2-15.0	2.5	14.7-18.1	2.7	17.1-21.5	2.8	19.2-24.3	2.9	21.7-26.8	3.1	24.7-29.4	3.2	26.7-31.3	3.4	29.4-34.1
								2.3	7.3-8.2	2.3	9.8-11.6	2.5	12.4-15.1	2.6	14.8-18.4	2.8	17.3-21.7	2.9	19.4-24.6	3.0	22.1-27.1	3.2	24.9-29.7	3.3	27.1-31.8	3.5	29.8-34.5
								2.4	7.4-8.4	2.4	9.9-11.9	2.6	12.6-15.3	2.7	14.9-18.6	2.9	17.5-21.9	3.0	19.6-24.8	3.1	22.3-27.5	3.3	25.1-30.0	3.4	27.5-32.4	3.6	30.3-35.1
								2.5	7.5-8.5	2.5	10.0-12.0	2.7	12.8-15.6	2.8	15.1-18.7	3.0	17.7-22.2	3.1	20.0-25.1	3.2	22.6-27.8	3.4	25.4-30.5	3.5	28.0-32.9	3.7	30.7-35.6
								2.6	7.6-8.6	2.6	10.2-12.2	2.8	12.9-15.7	2.9	15.2-19.0	3.1	17.8-22.4	3.2	20.1-25.4	3.3	22.8-28.1	3.5	25.7-31.0	3.6	28.3-33.4	3.8	31.1-36.0
								2.7	7.7-8.7	2.7	10.3-12.3	2.9	13.1-16.0	3.0	15.6-19.3	3.2	18.0-22.6	3.3	20.3-25.7	3.4	23.1-28.5	3.6	26.0-31.4	3.7	28.6-34.0	3.9	31.4-36.4
										2.8	10.3-12.4	3.0	13.2-16.1	3.1	15.7-19.5	3.3	18.1-22.8	3.4	20.6-26.0	3.5	23.4-28.7	3.7	26.3-31.7	3.8	28.8-34.2	4.0	31.7-36.8
										2.9	10.6-12.6	3.1	13.2-16.3	3.2	15.9-19.6	3.4	18.3-23.0	3.5	20.7-26.2	3.6	23.6-28.9	3.8	26.5-31.9	3.9	29.1-34.4	4.1	32.1-37.4
										3.0	10.7-12.7	3.2	13.4-16.4	3.3	15.9-19.8	3.5	18.6-23.2	3.6	20.8-26.4	3.7	23.7-29.1	3.9	26.7-32.2	4.0	29.3-34.8	4.2	32.3-37.7
										3.1	10.8-12.9	3.3	13.5-16.5	3.4	16.0-20.0	3.6	18.7-23.6	3.7	21.0-26.7	3.8	23.9-29.4	4.0	26.9-32.3	4.1	29.6-35.1	4.3	32.5-37.9
										3.2	10.8-13.0	3.4	13.6-16.7	3.5	16.2-20.1	3.7	18.8-23.7	3.8	21.2-26.9	3.9	24.2-29.8	4.1	27.1-32.7	4.2	30.1-35.3	4.4	32.7-38.3
										3.3	11.0-13.1	3.5	13.8-17.0	3.6	16.4-20.4	3.8	19.1-23.9	3.9	21.4-27.1	4.0	24.3-30.0	4.2	27.4-32.9	4.3	30.2-35.7	4.5	33.0-38.6
										3.4	11.0-13.3	3.6	13.9-17.0	3.7	16.5-20.6	3.9	19.2-24.0	4.0	21.6-27.4	4.1	24.5-30.1	4.3	27.6-33.2	4.4	30.5-36.0	4.6	33.3-38.9
										3.5	11.2-13.4	3.7	14.0-17.1	3.8	16.6-20.8	4.0	19.3-24.2	4.1	21.8-27.5	4.2	24.7-30.5	4.4	27.8-33.6	4.5	30.7-36.3	4.7	33.5-39.2
										3.6	11.3-13.5	3.8	14.1-17.4	3.9	16.7-20.9	4.1	19.5-24.3	4.2	21.9-27.7	4.3	24.8-30.6	4.5	28.0-33.8	4.6	30.9-36.5	4.8	33.7-39.4
												3.9	14.2-17.5	4.0	16.9-21.0	4.2	19.6-24.7	4.3	22.1-28.0	4.4	25.1-30.9	4.6	28.2-34.0	4.7	31.0-36.8	4.9	34.0-39.6
												4.0	14.3-17.5	4.1	17.1-21.2	4.3	19.7-24.8	4.4	22.3-28.1	4.5	25.2-31.0	4.7	28.3-34.2	4.8	31.2-37.1	5.0	34.3-40.1
												4.1	14.5-17.8	4.2	17.2-21.4	4.4	19.8-25.0	4.5	22.4-28.3	4.6	25.4-31.4	4.8	28.5-34.4	4.9	31.4-37.3	5.1	34.5-40.3
												4.2	14.7-17.9	4.3	17.3-21.6	4.5	20.0-25.1	4.6	22.6-28.5	4.7	25.6-31.5	4.9	28.6-34.6	5.0	31.6-37.5	5.2	34.7-40.6
												4.3	14.8-18.0	4.4	17.4-21.7	4.6	20.2-25.3	4.7	22.7-28.8	4.8	25.7-31.7	5.0	28.7-34.8	5.1	31.8-37.7	5.3	34.9-40.8
												4.4	14.9-18.0	4.5	17.5-21.8	4.7	20.3-25.5	4.8	22.8-29.0	4.9	25.8-31.9	5.1	29.0-35.0	5.2	31.9-37.9	5.4	35.1-41.1
														4.6	17.6-21.9	4.8	20.4-25.7	4.9	22.9-29.1	5.0	26.0-32.1	5.2	29.2-35.3	5.3	32.1-38.2	5.5	35.3-41.3
														4.7	17.7-22.1	4.9	20.5-25.8	5.0	23.1-29.3	5.1	26.1-32.2	5.3	29.4-35.5	5.4	32.3-38.5	5.6	35.5-41.6
														4.8	17.8-22.2	5.0	20.6-26.0	5.1	23.2-29.4	5.2	26.4-32.5	5.4	29.6-35.6	5.5	32.6-38.7	5.7	35.6-41.7
														4.9	18.0-22.4	5.1	20.7-26.1	5.2	23.3-29.6	5.3	26.5-32.6	5.5	29.7-35.8	5.6	32.7-38.8	5.8	35.8-42.0
														5.0	18.0-22.6	5.2	20.9-26.3	5.3	23.5-29.8	5.4	26.7-32.9	5.6	29.9-36.0	5.7	32.9-39.0	5.9	35.9-42.2
														5.1	18.2-22.7	5.3	21.0-26.4	5.4	23.7-30.0	5.5	26.8-33.1	5.7	30.1-36.3	5.8	33.0-39.2	6.0	36.1-42.4
														5.2	18.3-22.8	5.4	21.1-26.5	5.5	23.8-30.2	5.6	26.9-33.2	5.8	30.2-36.4	5.9	33.1-39.3	6.1	36.3-42.7
														5.3	18.4-22.9	5.5	21.2-26.7	5.6	23.9-30.3	5.7	27.0-33.3	5.9	30.3-36.5	6.0	33.3-39.6	6.2	36.5-42.9
																5.6	21.4-27.0	5.7	24.0-30.4	5.8	27.2-33.6	6.0	30.5-36.7	6.1	33.4-39.7	6.3	36.7-43.0
																5.7	21.5-27.1	5.8	24.2-30.5	5.9	27.3-33.7	6.1	30.6-36.9	6.2	33.6-39.9	6.4	36.8-43.2
																5.8	21.6-27.3	5.9	24.3-30.7	6.0	27.5-33.8	6.2	30.8-37.1	6.3	33.8-40.1	6.5	37.0-43.3
																5.9	21.7-27.5	6.0	24.4-30.9	6.1	27.6-34.0	6.3	30.9-37.3	6.4	34.0-40.3	6.6	37.1-43.5
																6.0	21.9-27.7	6.1	24.5-31.0	6.2	27.7-34.2	6.4	31.0-37.5	6.5	34.1-40.6	6.7	37.3-43.6
																6.1	22.0-27.9	6.2	24.6-31.2	6.3	27.9-34.4	6.5	31.1-37.6	6.6	34.2-40.8	6.8	37.5-43.8
																		6.3	24.7-31.4	6.4	28.0-34.6	6.6	31.2-37.7	6.7	34.4-41.0	6.9	37.7-44.1
																		6.4	24.9-31.6	6.5	28.2-34.7	6.7	31.3-37.9	6.8	34.5-41.1	7.0	38.0-44.4

RS-LS
RESEARCH PROGRAM
General
Eastern white pine study

SITE INDEX TABLE FOR JUVENILE EASTERN WHITE PINE STANDS IN U. S. FOREST SERVICE REGION 9

Site indexes 76 through 80

Age from seed, in years

2: Diameter o.b. (at 1/10 of total height) in inches	2: Total height in feet	4: Dia.	4: Height	6: Dia.	6: Height	8: Dia.	8: Height	10: Dia.	10: Height	12: Dia.	12: Height	14: Dia.	14: Height	16: Dia.	16: Height	18: Dia.	18: Height	20: Dia.	20: Height	22: Dia.	22: Height	24: Dia.	24: Height	26: Dia.	26: Height	28: Dia.	28: Height
0.4	1.6-1.7	0.5	2.8-2.9	0.6	3.5-3.8	0.8	4.9-5.1	0.5	4.1-4.5	0.6	6.3- 6.7	0.8	8.5- 9.7	0.9	10.6-11.7	1.1	12.9-14.8	1.2	15.0-16.6	1.3	17.1-18.4	1.5	19.4-21.0	1.6	21.4-22.7	1.8	23.8-25.4
.5	1.7-1.8	.6	3.1-3.2	.7	3.9-4.2	.9	5.1-5.4	.6	4.6-5.0	.7	6.6- 7.1	.9	9.3-10.1	1.0	11.1-12.2	1.2	14.1-15.4	1.3	15.6-17.4	1.4	17.4-18.8	1.6	20.1-21.5	1.7	21.9-23.2	1.9	24.6-26.0
		.7	3.1-3.2	.8	4.3-4.4	1.0	5.4-5.6	.7	5.1-5.4	.8	7.1- 7.9	1.0	9.8-10.7	1.1	11.9-13.6	1.3	14.6-16.4	1.4	16.5-18.1	1.5	18.2-19.7	1.7	20.9-22.5	1.8	22.7-24.3	2.0	25.5-27.2
		.8	3.3-3.4	.9	4.4-4.6	1.1	5.6-5.9	.8	5.5-5.7	.9	7.8- 8.5	1.1	10.5-11.6	1.2	12.9-14.1	1.4	15.6-17.1	1.5	17.1-19.3	1.6	18.9-20.5	1.8	21.5-22.9	1.9	23.7-25.4	2.1	26.4-27.8
		.9	3.4-3.5	1.0	4.5-4.7	1.2	5.8-6.1	.9	5.9-6.1	1.0	8.3- 9.0	1.2	11.1-12.2	1.3	13.3-14.6	1.5	16.0-17.7	1.6	18.2-20.1	1.7	19.6-21.9	1.9	22.1-24.4	2.0	24.5-26.5	2.2	27.0-29.0
		1.0	3.5-3.6	1.1	4.7-4.9	1.3	6.0-6.2	1.0	6.1-6.4	1.1	8.7- 9.6	1.3	11.6-12.8	1.4	13.8-15.2	1.6	16.7-18.4	1.7	18.7-20.8	1.8	20.8-22.8	2.0	23.5-25.4	2.1	25.3-27.0	2.3	27.9-29.5
				1.2	4.8-5.0	1.4	6.1-6.3	1.1	6.4-6.8	1.2	9.1- 9.9	1.4	12.2-13.3	1.5	14.4-15.8	1.7	17.1-19.1	1.8	19.5-21.6	1.9	21.4-23.6	2.1	24.2-26.4	2.2	25.9-27.6	2.4	28.5-30.2
				1.3	5.0-5.2	1.5	6.2-6.6	1.2	6.7-7.0	1.3	9.5-10.1	1.5	12.5-13.7	1.6	14.9-16.5	1.8	17.8-19.7	1.9	20.0-22.4	2.0	22.1-24.5	2.2	24.9-26.9	2.3	26.4-28.6	2.5	29.0-31.4
				1.4	5.1-5.3	1.6	6.4-6.7	1.3	6.9-7.2	1.4	9.7-10.7	1.6	12.9-13.9	1.7	15.4-17.1	1.9	18.4-20.4	2.0	20.8-23.1	2.1	22.7-24.9	2.3	25.4-27.4	2.4	27.2-29.1	2.6	29.9-31.9
				1.5	5.1-5.4	1.7	6.5-6.8	1.4	7.1-7.4	1.5	10.2-11.0	1.7	13.2-14.6	1.8	16.1-17.4	2.0	18.9-21.0	2.1	21.3-23.9	2.2	23.2-25.4	2.4	25.8-28.4	2.5	27.7-30.2	2.7	30.5-32.6
				1.6	5.3-5.5	1.8	6.7-6.9	1.5	7.2-7.6	1.6	10.4-11.2	1.8	13.6-15.0	1.9	16.3-18.4	2.1	19.5-21.4	2.2	21.9-24.3	2.3	23.8-26.2	2.5	26.6-28.8	2.6	28.5-30.8	2.8	31.1-33.1
						1.9	6.7-7.1	1.6	7.4-7.7	1.7	10.6-11.3	1.9	14.0-15.2	2.0	17.0-18.7	2.2	19.8-22.0	2.3	22.3-24.7	2.4	24.4-27.1	2.6	27.1-29.3	2.7	29.0-31.3	2.9	31.7-34.3
						2.0	6.9-7.2	1.7	7.5-7.9	1.8	10.8-11.6	2.0	14.2-15.4	2.1	17.2-18.9	2.3	20.3-22.3	2.4	22.8-25.1	2.5	25.0-27.5	2.7	27.5-30.3	2.8	29.6-31.9	3.0	32.6-34.9
						2.1	7.0-7.3	1.8	7.7-8.1	1.9	11.0-11.9	2.1	14.4-15.7	2.2	17.4-19.0	2.4	20.6-22.7	2.5	23.2-25.8	2.6	25.5-28.0	2.8	28.2-30.8	2.9	30.1-32.4	3.1	32.9-35.2
								1.9	7.8-8.3	2.0	11.3-12.1	2.2	14.6-15.8	2.3	17.6-19.3	2.5	20.8-23.0	2.6	23.7-26.2	2.7	25.9-28.4	2.9	28.8-31.3	3.0	30.6-32.9	3.2	33.2-35.5
								2.0	8.0-8.4	2.1	11.5-12.3	2.3	14.9-16.3	2.4	17.9-19.6	2.6	21.2-23.3	2.7	24.1-26.6	2.8	26.4-28.9	3.0	29.1-31.6	3.1	31.1-33.5	3.3	33.7-36.1
								2.1	8.1-8.5	2.2	11.6-12.4	2.4	15.1-16.5	2.5	18.2-20.1	2.7	21.6-23.7	2.8	24.4-27.0	2.9	26.9-29.3	3.1	29.5-31.8	3.2	31.4-34.0	3.4	34.2-36.7
								2.2	8.2-8.6	2.3	11.7-12.7	2.5	15.2-16.6	2.6	18.5-20.3	2.8	21.8-24.0	2.9	24.7-27.4	3.0	27.2-29.7	3.2	29.8-32.3	3.3	31.9-34.5	3.5	34.6-37.3
								2.3	8.3-8.8	2.4	12.0-12.9	2.6	15.4-16.9	2.7	18.7-20.5	2.9	22.0-24.3	3.0	24.9-27.6	3.1	27.6-30.2	3.3	30.1-32.7	3.4	32.5-35.1	3.6	35.2-37.8
								2.4	8.5-8.9	2.5	12.1-13.0	2.7	15.7-17.1	2.8	18.8-20.6	3.0	22.3-24.6	3.1	25.2-27.8	3.2	27.9-30.6	3.4	30.6-33.2	3.5	33.0-35.6	3.7	35.7-38.2
								2.5	8.6-9.0	2.6	12.3-13.2	2.8	15.8-17.3	2.9	19.1-20.9	3.1	22.5-24.8	3.2	25.5-28.2	3.3	28.2-31.0	3.5	31.1-33.7	3.6	33.5-36.2	3.8	36.1-38.5
								2.6	8.7-9.1	2.7	12.4-13.4	2.9	16.1-17.5	3.0	19.4-21.2	3.2	22.7-25.0	3.3	25.8-28.5	3.4	28.6-31.3	3.6	31.5-34.2	3.7	34.1-36.7	3.9	36.5-39.0
										2.8	12.5-13.5	3.0	16.2-17.8	3.1	19.6-21.5	3.3	22.9-25.3	3.4	26.1-28.9	3.5	28.8-31.5	3.7	31.8-34.7	3.8	34.3-37.0	4.0	36.9-39.6
										2.9	12.7-13.7	3.1	16.4-17.9	3.2	19.7-21.7	3.4	23.1-25.5	3.5	26.3-29.1	3.6	29.0-31.7	3.8	32.0-34.9	3.9	34.5-37.3	4.1	37.5-40.2
										3.0	12.8-13.8	3.2	16.5-18.0	3.3	19.9-21.9	3.5	23.3-26.0	3.6	26.5-29.3	3.7	29.2-31.9	3.9	32.3-35.1	4.0	34.9-37.8	4.2	37.8-40.5
										3.1	13.0-14.0	3.3	16.6-18.2	3.4	20.1-22.0	3.6	23.7-26.2	3.7	26.8-29.7	3.8	29.5-32.3	4.0	32.4-35.2	4.1	35.2-38.1	4.3	38.0-40.8
										3.2	13.1-14.1	3.4	16.8-18.4	3.5	20.2-22.2	3.7	23.8-26.3	3.8	27.0-30.0	3.9	29.9-32.8	4.1	32.8-35.7	4.2	35.4-38.3	4.4	38.4-41.4
										3.3	13.2-14.2	3.5	17.1-18.6	3.6	20.5-22.5	3.8	24.0-26.5	3.9	27.2-30.1	4.0	30.1-33.0	4.2	33.0-35.9	4.3	35.8-38.6	4.5	38.7-41.7
										3.4	13.4-14.3	3.6	17.1-18.7	3.7	20.7-22.8	3.9	24.1-26.6	4.0	27.5-30.5	4.1	30.2-33.2	4.3	33.3-36.1	4.4	36.1-38.9	4.6	39.0-42.0
												3.7	17.2-18.8	3.8	20.9-23.0	4.0	24.3-26.8	4.1	27.6-30.7	4.2	30.6-33.7	4.4	33.7-36.6	4.5	36.4-39.2	4.7	39.3-42.2
												3.8	17.5-19.1	3.9	21.0-23.1	4.1	24.4-27.3	4.2	27.8-30.9	4.3	30.7-33.9	4.5	33.9-36.9	4.6	36.6-39.4	4.8	39.5-42.4
												3.9	17.6-19.2	4.0	21.1-23.3	4.2	24.8-27.5	4.3	28.1-31.1	4.4	31.0-34.0	4.6	34.1-37.1	4.7	36.9-40.0	4.9	39.7-42.6
												4.0	17.6-19.3	4.1	21.3-23.4	4.3	24.9-27.6	4.4	28.2-31.2	4.5	31.1-34.1	4.7	34.3-37.4	4.8	37.2-40.3	5.0	40.2-43.2
												4.1	17.9-19.5	4.2	21.5-23.6	4.4	25.1-27.8	4.5	28.4-31.4	4.6	31.5-34.6	4.8	34.5-37.6	4.9	37.4-40.5	5.1	40.4-43.5
														4.3	21.7-23.8	4.5	25.2-27.9	4.6	28.6-31.6	4.7	31.6-34.8	4.9	34.7-37.9	5.0	37.6-40.7	5.2	40.7-43.8
														4.4	21.8-23.9	4.6	25.4-28.1	4.7	28.9-32.0	4.8	31.8-35.0	5.0	34.9-38.1	5.1	37.8-40.9	5.3	40.9-44.1
														4.5	21.9-24.0	4.7	25.6-28.3	4.8	29.1-32.2	4.9	32.0-35.2	5.1	35.1-38.4	5.2	38.0-41.1	5.4	41.2-44.3
														4.6	22.0-24.1	4.8	25.8-28.5	4.9	29.2-32.4	5.0	32.2-35.3	5.2	35.4-38.6	5.3	38.3-41.6	5.5	41.4-44.5
														4.7	22.2-24.4	4.9	25.9-28.6	5.0	29.4-32.6	5.1	32.3-35.4	5.3	35.6-38.8	5.4	38.6-41.8	5.6	41.7-44.8
														4.8	22.3-24.6	5.0	26.1-28.8	5.1	29.5-32.8	5.2	32.6-35.6	5.4	35.7-39.0	5.5	38.8-41.9	5.7	41.8-45.0
														4.9	22.5-24.7	5.1	26.2-28.9	5.2	29.7-33.0	5.3	32.7-35.8	5.5	35.9-39.1	5.6	38.9-42.1	5.8	42.1-45.3
																5.2	26.4-29.1	5.3	29.9-33.2	5.4	33.0-36.3	5.6	36.1-39.4	5.7	39.1-42.3	5.9	42.3-45.5
																5.3	26.5-29.2	5.4	30.1-33.4	5.5	33.2-36.4	5.7	36.4-39.6	5.8	39.3-42.5	6.0	42.5-45.8
																5.4	26.6-29.4	5.5	30.3-33.6	5.6	33.3-36.6	5.8	36.5-39.7	5.9	39.4-42.7	6.1	42.8-46.1
																5.5	26.8-29.6	5.6	30.4-33.7	5.7	33.4-36.7	5.9	36.6-39.9	6.0	39.7-43.0	6.2	43.0-46.3
																5.6	27.1-29.9	5.7	30.5-33.8	5.8	33.7-37.0	6.0	36.8-40.0	6.1	39.8-43.2	6.3	43.1-46.4
																		5.8	30.6-33.9	5.9	33.8-37.2	6.1	37.0-40.3	6.2	40.0-43.4	6.4	43.3-46.6
																		5.9	30.8-34.1	6.0	33.9-37.3	6.2	37.2-40.6	6.3	40.2-43.5	6.5	43.4-46.7
																		6.0	31.0-34.3	6.1	34.1-37.5	6.3	37.4-40.8	6.4	40.4-43.7	6.6	43.6-46.9
																		6.1	31.1-34.5	6.2	34.3-37.6	6.4	37.6-41.0	6.5	40.7-44.0	6.7	43.7-47.1
																		6.2	31.3-34.7	6.3	34.5-37.9	6.5	37.7-41.2	6.6	40.9-44.3	6.8	43.9-47.3
																		6.3	31.5-34.9	6.4	34.7-38.1	6.6	37.8-41.4	6.7	41.1-44.5	6.9	44.2-47.6
																		6.4	31.7-35.1	6.5	34.8-38.2	6.7	38.0-41.5	6.8	41.2-44.6	7.0	44.5-47.9

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

CALCULATION AID

INFO-PSW
PACIFIC SOUTHWEST RESEARCH STATION
P. O. Box 245
Berkeley, CA 94701

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

DIVISION OF FOREST ECONOMICS RESEARCH
IN COOPERATION WITH
DIVISION OF FOREST PEST CONTROL

LAKE STATES BLISTER RUST CONTROL EVALUATION CALCULATION AID

MODEL I
1960

SITE INDEX 60

AVERAGE DBH OF CROP TREES 5.6-6.5
35
A

CROP TREES PER 0.1 ACRE 4-38 | 3
THINNING YES | N

PROPORTION OF STAND SAVED BY RUST CONTROL

LENGTH OF CONTROL PERIOD		0-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
HAZARD ZONE	HIGH	.00	.12	.22	.31	.39	.46	.53	.58	.62	.67	.71	B
	MEDIUM	.00	.05	.11	.15	.20	.24	.28	.32	.36	.39	.42	
	LOW	.00	.01	.02	.03	.04	.06	.07	.08	.09	.10	.11	

STUMPAGE VALUE AT TIME OF HARVEST

HARVEST DATE	1981-1990	1991-2000	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2051-2060	2061-2070	2071-2080	2081-2090	2091-2100	
	25	27	29	31	33	35	37	39	41	43	45	47	C
	193	202	210	218	227	235	244	252	260	269	277	285	D
	29	30	31	32	33	34	35	36	37	38	39	40	E

COST PER MAN-DAY OF RUST CONTROL

LENGTH OF INVESTMENT PERIOD		31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	
NUMBER OF FUTURE WORKINGS	ONE	83	106	136	174	223	285	365	467	599	F
	TWO	79	101	130	166	213	272	349	446	571	
	THREE	77	98	126	161	206	264	338	432	553	
	FOUR	75	96	123	158	202	258	331	423	542	

STAND VOLUME AND VALUE FACTORS

			ROTATION AGE 80
7.7	3	G	
8.3	6	H	
9.5	4	I	
.19		J	
.70		K	
.07		L	
2.2		M	

			ROTATION AGE 100
2.4	4	G	
2.7	8	H	
4.5	5	I	
.22		J	
.77		K	
.17		L	
7.1		M	

			ROTATION AGE 120
7.0	5	G	
7.0	9	H	
8.5	6	I	
.24		J	
.78		K	
.23		L	
2.1		M	

THIS INSERT IS FOR SITE INDEX 40

444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444

0-0.5	0.6-1.5	1.6-2.5	2.6-3.5	3.6-4.5	4.6-5.5	5.6-6.5	6.6-7.5
11	17	23	28	33	39	47	56

1-6 NO	1-6 YES	7-13 NO	7-13 YES	14-19 NO	14-19 YES	20-26 NO	20-26 YES	27-32 NO	27-32 YES	33-39 NO	33-39 YES	40-45 NO	40-45 YES	46-52 NO	46-52 YES	53-58 NO	53-58 YES	59-65 NO	59-65 YES
2.6	THINNING NOT APPLICABLE	4.5	THINNING NOT APPLICABLE	5.9	THINNING NOT APPLICABLE	6.9	THINNING NOT APPLICABLE	7.5	THINNING NOT APPLICABLE	7.6	THINNING NOT APPLICABLE	7.6	THINNING NOT APPLICABLE	7.7	THINNING NOT APPLICABLE	7.7	THINNING NOT APPLICABLE	7.8	THINNING NOT APPLICABLE
5.6		9.6		12.5		14.1		14.9		15.2		15.3		15.5		15.6		15.8	
3.5		5.8		7.3		8.2		8.4		8.6		8.6		8.7		8.8		8.9	
.18		.15		.13		.11		.10		.10		.10		.10		.10		.10	
.68		.65		.65		.65		.65		.65		.65		.65		.65		.65	
-.03		-.07		-.10		-.12		-.13		-.13		-.13		-.13		-.13		-.13	
0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
6.4	THINNING NOT APPLICABLE	7.9	THINNING NOT APPLICABLE	10.4	THINNING NOT APPLICABLE	11.9	THINNING NOT APPLICABLE	12.9	THINNING NOT APPLICABLE	13.2	THINNING NOT APPLICABLE	13.5	THINNING NOT APPLICABLE	13.8	THINNING NOT APPLICABLE	14.0	THINNING NOT APPLICABLE	14.3	THINNING NOT APPLICABLE
16.4		19.7		25.5		30.6		31.5		32.0		32.1		33.5		33.6		33.7	
10.8		12.7		16.0		19.1		19.2		19.3		19.5		20.1		20.2		20.3	
.25		.24		.21		.19		.17		.17		.17		.17		.16		.15	
.73		.71		.69		.68		.67		.67		.67		.67		.66		.66	
.05		.02		-.01		-.03		-.05		-.06		-.07		-.07		-.07		-.08	
0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
10.2	THINNING NOT APPLICABLE	11.3	THINNING NOT APPLICABLE	12.3	THINNING NOT APPLICABLE	13.4	THINNING NOT APPLICABLE	14.5	THINNING NOT APPLICABLE	15.6	THINNING NOT APPLICABLE	16.6	THINNING NOT APPLICABLE	17.7	THINNING NOT APPLICABLE	18.8	18.0	19.8	18.0
24.4		27.5		29.9		32.4		35.4		37.5		40.6		42.6		44.8	43.0	45.8	43.0
16.3		18.2		19.7		21.2		23.0		24.3		26.1		27.0		28.0	27.2	28.1	27.2
.25		.25		.25		.23		.21		.20		.19		.18		.17	.17	.17	.17
.64		.64		.64		.64		.63		.63		.63		.63		.63	.63	.63	.63
.08		.07		.06		.05		.04		.02		.01		.00		-.02	.00	-.04	.00
0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	0.4	0.0	1.1

THE SILLCOCKS-MILLER CO
MAPLEWOOD, NEW JERSEY

THIS INSERT IS FOR SITE INDEX 50

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0-0.5	0.6-1.5	1.6-2.5	2.6-3.5	3.6-4.5	4.6-5.5	5.6-6.5	6.6-7.5	7.6-8.5	8.6-9.5
9	15	20	25	29	33	38	44	50	58

1-6 NO	1-6 YES	7-11 NO	7-11 YES	12-17 NO	12-17 YES	18-23 NO	18-23 YES	24-28 NO	24-28 YES	29-34 NO	29-34 YES	35-40 NO	35-40 YES	41-45 NO	41-45 YES	46-51 NO	46-51 YES	52-57 NO	52-57 YES
4.1	THINNING NOT APPLICABLE	7.1	THINNING NOT APPLICABLE	9.6	THINNING NOT APPLICABLE	11.3	THINNING NOT APPLICABLE	12.6	THINNING NOT APPLICABLE	13.5	THINNING NOT APPLICABLE	14.0	THINNING NOT APPLICABLE	14.4	THINNING NOT APPLICABLE	14.5	THINNING NOT APPLICABLE	14.5	THINNING NOT APPLICABLE
9.8		17.3		23.1		27.0		29.2		30.9		31.8		32.2		32.5		32.6	
6.6		11.3		14.7		16.9		18.0		18.7		19.0		19.3		19.3		19.4	
.26		.24		.22		.19		.18		.17		.17		.16		.16		.16	
.70		.69		.68		.67		.67		.67		.66		.66		.66		.66	
.08		.03		-.01		-.03		-.05		-.07		-.08		-.08		-.08		-.08	
0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
12.6	THINNING NOT APPLICABLE	15.4	THINNING NOT APPLICABLE	19.9	THINNING NOT APPLICABLE	22.6	21.6	24.2	21.6	24.4	21.6	24.6	21.6	24.7	21.6	24.9	21.6	25.1	21.6
26.9		33.5		44.2		48.9	46.4	50.7	46.4	51.8	46.4	52.4	46.4	53.0	46.4	53.9	46.4	54 6	46.4
18.5		22.8		29.6		32.2	30.4	32.6	30.4	33.3	30.4	33.7	30.4	34.1	30.4	34.5	30.4	34.9	30.4
.24		.24		.19		.17	.18	.17	.18	.17	.18	.17	.18	.16	.18	.16	.18	.16	.18
.72		.71		.69		.67	.66	.64	.66	.64	.66	.63	.66	.63	.66	.63	.66	.62	.66
.11		.09		.05		.01	.02	-.01	.02	-.01	.02	-.02	.02	-.02	.02	-.03	.02	-.03	.02
0.0		0.0		0.0		0.0	0.6	0.0	1.6	0.0	1.7	0.0	1.8	0.0	2.0	0.0	2.1	0.0	2.2
14.1	THINNING NOT APPLICABLE	22.3	THINNING NOT APPLICABLE	28.2	25.6	31.0	25.6	31.3	25.6	31.5	25.6	31.8	25.6	32.3	25.6	32.5	25.6	32.5	25.6
28.6		45.8		59.3	53.1	61.8	53.1	64.7	53.1	65.0	53.1	65.5	53.1	65.6	53.1	65.7	53.1	65.9	53.1
20.2		31.6		40.5	36.4	41.5	36.4	43.0	36.4	43.1	36.4	43.7	36.4	43.9	36.4	44.0	36.4	44.1	36.4
.25		.24		.19	.20	.17	.20	.17	.20	.17	.20	.17	.20	.17	.20	.17	.20	.17	.20
.75		.73		.72	.72	.71	.72	.71	.72	.70	.72	.70	.72	.70	.72	.70	.72	.70	.72
.18		.13		.09	.11	.08	.11	.05	.11	.04	.11	.03	.11	.02	.11	.02	.11	.02	.11
0.0		0.0		0.0	1.6	0.0	3.7	0.0	4.3	0.0	4.5	0.0	4.7	0.0	5.1	0.0	5.2	0.0	5.3

THE SILLCOCKS-MILLER CO.
MAPLEWOOD, NEW JERSEY

THIS INSERT IS FOR SITE INDEX 60

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0-0.5	0.6-1.5	1.6-2.5	2.6-3.5	3.6-4.5	4.6-5.5	5.6-6.5	6.6-7.5	7.6-8.5	8.6-9.5	9.6-10.5
8	14	18	23	27	31	35	38	42	47	53

1-5 NO	1-5 YES	6-10 NO	6-10 YES	11-14 NO	11-14 YES	15-19 NO	15-19 YES	20-24 NO	20-24 YES	25-29 NO	25-29 YES	30-33 NO	30-33 YES	34-38 NO	34-38 YES	39-43 NO	39-43 YES	44-48 NO	44-48 YES
7.8	THINNING NOT APPLICABLE	13.8	THINNING NOT APPLICABLE	19.0	THINNING NOT APPLICABLE	22.7	THINNING NOT APPLICABLE	25.9	THINNING NOT APPLICABLE	28.3	27.7	30.0	27.7	31.4	27.7	32.4	27.7	33.2	27.7
15.2		28.6		39.7		47.9		54.8		60.0	58.3	62.9	58.3	64.3	58.3	65.2	58.3	66.6	58.3
10.9		20.2		27.2		32.9		37.3		40.5	39.5	41.9	39.5	42.2	39.5	42.4	39.5	43.1	39.5
.25		.25		.25		.24		.19		.18	.19	.17	.19	.17	.19	.17	.19	.16	.19
.78		.76		.75		.73		.71		.70	.70	.69	.70	.68	.70	.67	.70	.67	.70
.21		.17		.13		.11		.09		.07	.07	.05	.07	.03	.07	.01	.07	.00	.07
0.0		0.0		0.0		0.0		0.0		0.0	0.3	0.0	1.3	0.0	2.2	0.0	3.0	0.0	3.5
13.1	THINNING NOT APPLICABLE	21.8	THINNING NOT APPLICABLE	29.0	THINNING NOT APPLICABLE	33.7	32.4	37.0	32.4	39.5	32.4	41.3	32.4	42.8	32.4	43.8	32.4	44.6	32.4
23.4		40.7		55.5		65.6	62.7	72.5	62.7	78.0	62.7	81.6	62.7	83.1	62.7	85.5	62.7	86.5	62.7
17.1		29.4		39.6		46.6	44.5	51.0	44.5	54.6	44.5	56.9	44.5	57.4	44.5	58.6	44.5	59.2	44.5
.24		.24		.24		.21	.22	.19	.22	.18	.22	.17	.22	.17	.22	.17	.22	.17	.22
.79		.79		.78		.77	.77	.76	.77	.75	.77	.74	.77	.73	.77	.72	.77	.71	.77
.27		.23		.19		.17	.17	.15	.17	.13	.17	.11	.17	.10	.17	.09	.17	.06	.17
0.0		0.0		0.0		0.0	0.8	0.0	2.9	0.0	4.9	0.0	6.2	0.0	7.1	0.0	8.6	0.0	9.3
17.6	THINNING NOT APPLICABLE	28.7	THINNING NOT APPLICABLE	37.2	37.0	42.1	37.0	45.5	37.0	48.0	37.0	49.8	37.0	51.3	37.0	52.3	37.0	53.2	37.0
29.5		50.5		67.7	67.0	76.8	67.0	82.6	67.0	89.0	67.0	92.5	67.0	94.9	67.0	96.3	67.0	96.6	67.0
21.8		36.9		49.0	48.5	55.2	48.5	59.1	48.5	63.4	48.5	65.6	48.5	66.9	48.5	67.6	48.5	67.1	48.5
.24		.24		.24	.24	.21	.24	.19	.24	.19	.24	.18	.24	.17	.24	.17	.24	.17	.24
.78		.78		.78	.78	.77	.78	.78	.78	.77	.78	.76	.78	.75	.78	.74	.78	.74	.78
.31		.27		.23	.23	.21	.23	.19	.23	.17	.23	.15	.23	.14	.23	.13	.23	.11	.23
0.0		0.0		0.0	0.1	0.0	3.5	0.0	6.4	0.0	9.3	0.0	10.9	0.0	12.1	0.0	14.0	0.0	14.8

THE SILLCOCKS-MILLER CO.
MAPLEWOOD, NEW JERSEY

THIS INSERT IS FOR SITE INDEX 80

0-0.5 6	0.6-1.5 12		1.6-2.5 15		2.6-3.5 20	3.6-4.5 24		4.6-5.5 27		5.6-6.5 29	6.6-7.5 32		7.6-8.5 35		8.6-9.5 39	9.6-10.5 42		10.6-11.5 46	
1-3 NO	1-3 YES	4-7 NO	4-7 YES	8-11 NO	8-11 YES	12-15 NO	12-15 YES	16-19 NO	16-19 YES	20-23 NO	20-23 YES	24-27 NO	24-27 YES	28-31 NO	28-31 YES	32-35 NO	32-35 YES	36-39 NO	36-39 YES
9.4	THINNING NOT APPLICABLE	17.4	THINNING NOT APPLICABLE	26.2	THINNING NOT APPLICABLE	31.0	THINNING NOT APPLICABLE	36.6	THINNING NOT APPLICABLE	41.4	41.1	45.5	41.1	49.3	41.1	52.5	41.1	55.6	41.1
16.2		31.2		48.9		58.4		70.3		81.2	80.8	90.1	80.8	98.4	80.8	105.2	80.8	111.2	80.8
12.1		23.3		36.2		42.9		51.5		59.2	59.0	65.3	59.0	70.8	59.0	75.0	59.0	78.0	59.0
.27		.27		.28		.27		.27		.24	.24	.22	.24	.20	.24	.19	.24	.18	.24
.81		.81		.80		.80		.79		.78	.78	.77	.78	.76	.78	.75	.78	.74	.78
.35		.31		.28		.26		.24		.22	.22	.20	.22	.17	.22	.15	.22	.11	.22
0.0		0.0		0.0		0.0		0.0		0.0	0.1	0.0	2.7	0.0	5.6	0.0	7.8	0.0	10.0
17.3	THINNING NOT APPLICABLE	29.7	THINNING NOT APPLICABLE	40.4	THINNING NOT APPLICABLE	48.2	THINNING NOT APPLICABLE	54.2	48.7	57.1	48.7	63.2	48.7	67.0	48.7	70.1	48.7	73.1	48.7
24.1		44.8		63.8		78.8		90.2	80.0	100.9	80.0	109.8	80.0	116.5	80.0	122.5	80.0	127.6	80.0
18.3		34.0		48.2		59.2		67.6	60.2	75.4	60.2	81.7	60.2	86.1	60.2	90.1	60.2	92.5	60.2
.24		.23		.25		.26		.25	.26	.24	.26	.22	.26	.21	.26	.20	.26	.19	.26
.82		.82		.81		.81		.80	.80	.80	.80	.79	.80	.79	.80	.79	.80	.79	.80
.41		.38		.36		.33		.31	.33	.30	.33	.28	.33	.26	.33	.24	.33	.20	.33
0.0		0.0		0.0		0.0		0.0	3.5	0.0	7.2	0.0	11.0	0.0	15.5	0.0	18.1	0.0	20.6
18.9	THINNING NOT APPLICABLE	31.2	THINNING NOT APPLICABLE	42.6	THINNING NOT APPLICABLE	54.9	THINNING NOT APPLICABLE	66.2	55.9	72.5	55.9	77.8	55.9	80.1	55.9	82.4	55.9	84.7	55.9
22.9		37.9		54.4		72.5		81.4	81.4	87.0	81.4	96.8	81.4	107.6	81.4	120.9	81.4	133.8	81.4
17.4		28.8		41.3		55.0		61.8	61.8	66.0	61.8	73.2	61.8	81.1	61.8	90.5	61.8	98.4	61.8
.24		.24		.24		.24		.24	.24	.24	.24	.24	.24	.24	.24	.21	.24	.19	.24
.86		.85		.84		.83		.82	.82	.81	.82	.80	.82	.79	.82	.78	.82	.77	.82
.42		.42		.41		.40		.38	.38	.36	.38	.35	.38	.34	.38	.31	.38	.25	.38
0.0		0.0		0.0		0.0		0.0	7.8	0.0	14.0	0.0	20.0	0.0	24.9	0.0	27.3	0.0	29.7

THE SILLCOCKS-MILLER CO.
MAPLEWOOD, NEW JERSEY

THIS INSERT IS FOR SITE INDEX 70

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0-0.5 7	0.6-1.5 13		1.6-2.5 16		2.6-3.5 21	3.6-4.5 25		4.6-5.5 28		5.6-6.5 31	6.6-7.5 35		7.6-8.5 38	8.6-9.5 42		9.6-10.5 47		10.6-11.5 52	
1-4 NO	1-4 YES	5-8 NO	5-8 YES	9-12 NO	9-12 YES	13-16 NO	13-16 YES	17-20 NO	17-20 YES	21-25 NO	21-25 YES	26-29 NO	26-29 YES	30-33 NO	30-33 YES	34-37 NO	34-37 YES	38-42 NO	38-42 YES
9.0	THINNING NOT APPLICABLE	16.2	THINNING NOT APPLICABLE	23.9	THINNING NOT APPLICABLE	27.6	THINNING NOT APPLICABLE	31.9	THINNING NOT APPLICABLE	35.3	32.4	38.0	32.4	40.4	32.4	42.2	32.4	43.8	32.4
16.7		30.7		45.2		52.6		62.2		68.3	63.1	72.7	63.1	74.0	63.1	75.0	63.1	75.9	63.1
12.2		22.3		32.4		37.3		43.8		47.6	44.4	50.5	44.4	51.1	44.4	51.3	44.4	51.5	44.4
.28		.27		.26		.25		.23		.20	.22	.19	.22	.18	.22	.17	.22	.17	.22
.78		.78		.77		.77		.76		.75	.76	.74	.76	.73	.76	.72	.76	.71	.76
.27		.23		.20		.17		.15		.13	.15	.12	.15	.08	.15	.05	.15	.02	.15
0.0		0.0		0.0		0.0		0.0		0.0	1.7	0.0	3.5	0.0	5.0	0.0	6.8	0.0	7.9
15.3	THINNING NOT APPLICABLE	26.0	THINNING NOT APPLICABLE	35.0	THINNING NOT APPLICABLE	41.4	40.6	46.1	40.6	49.8	40.6	52.8	40.6	55.5	40.6	57.5	40.6	59.4	40.6
22.7		41.5		60.4		69.8	68.5	79.3	68.5	85.6	68.5	92.1	68.5	96.7	68.5	101.0	68.5	103.2	68.5
17.0		30.7		44.3		51.0	50.2	57.7	50.2	62.0	50.2	66.3	50.2	69.2	50.2	71.9	50.2	72.4	50.2
.24		.25		.25		.24	.25	.23	.25	.21	.25	.19	.25	.19	.25	.18	.25	.18	.25
.81		.81		.81		.81	.81	.80	.81	.80	.81	.79	.81	.78	.81	.77	.81	.75	.81
.35		.31		.28		.25	.25	.23	.25	.22	.25	.20	.25	.18	.25	.16	.25	.13	.25
0.0		0.0		0.0		0.0	0.5	0.0	3.5	0.0	6.4	0.0	9.3	0.0	11.3	0.0	14.4	0.0	16.0
20.8	THINNING NOT APPLICABLE	34.3	THINNING NOT APPLICABLE	45.1	THINNING NOT APPLICABLE	51.7	45.8	56.7	45.8	60.6	45.8	63.8	45.8	66.5	45.8	68.7	45.8	70 7	45.8
28.0		49.5		67.5		79.9	69.5	88.8	69.5	96.4	69.5	102.1	69.5	107.2	69.5	111.4	69.5	119.0	69.5
21.2		37.1		50.2		59.1	51.7	65.5	51.7	70.8	51.7	74.7	51.7	78.1	51.7	80.7	51.7	85.1	51.7
.23		.24		.24		.24	.24	.23	.24	.21	.24	.20	.24	.19	.24	.19	.24	.18	.24
.83		.83		.83		.83	.83	.82	.83	.82	.83	.81	.83	.80	.83	.80	.83	.78	.83
.39		.35		.32		.30	.32	.28	.32	.27	.32	.25	.32	.23	.32	.21	.32	.19	.32
0.0		0.0		0.0		0.0	4.1	0.0	9.2	0.0	12.6	0.0	16.5	0.0	19.0	0.0	23.6	0.0	25.7

THE SILLCOCKS-MILLER CO.